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From The Illustrated War News (London)

Blowing up a German stronghold with high explosives

CLEARING THE WAY FOR AN ADVANCE [See page 115]

The Complexity of the Atom*

Considered from Both a Chemical and a Physical Point of View

By Prof. F. Soddy, F.R.S.

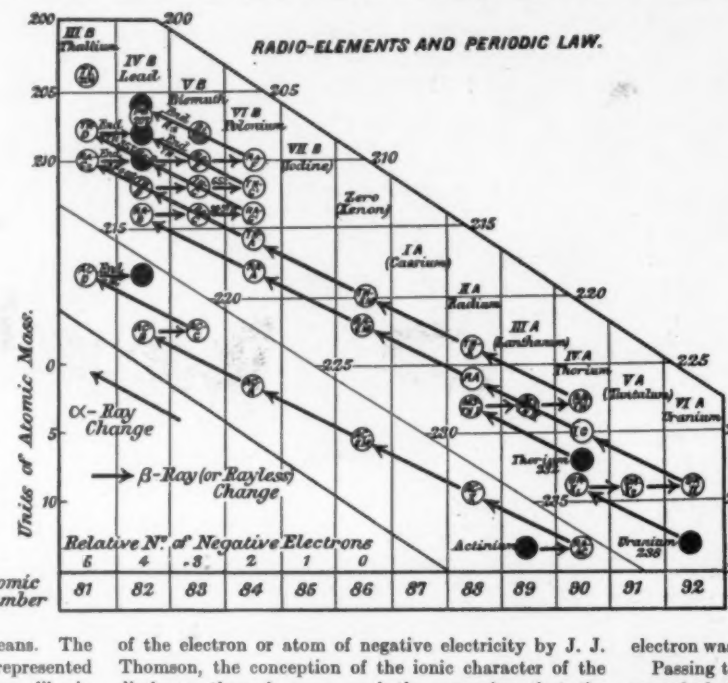
THE chemist has reason to complain that the atoms of the physicists of our days may explain radiation and electromagnetic phenomena, but do not tell him how to understand chemical affinity and the vast variety of reactions. Though the problems of theoretical chemistry are largely those of physical chemistry, the chemist and physicist pursue each his own line of research, each sufficiently difficult, and it may still be said that physicists and chemists often do not understand one another. When Prof. P. Langevin, on March 23d, delivered the Guthrie lecture on "Molecular Orientation" before the Physical Society, he confined himself almost to magnetism and radiation; and when, a week later, Prof. A. Scott delivered his address as retiring president to the Chemical Society on "The Atomic Theory," he dwelt chiefly on the work of Stas and on Prout's hypothesis and the exact quantitative basis of the periodic law, without referring to modern speculations as to the structure of the atom. In his Royal Institution discourse, recently on "The Complexity of the Atom," Prof. F. Soddy, F.R.S., of Aberdeen, really approached the problem from the standpoints of both the chemist and physicist, with all the acumen and boldness that one expects from one of the originators of the theory of radioactive disintegration. It was a very remarkable discourse, which deserves the fullest attention.

The elements of the chemist, Professor Soddy said, were known to be complex in three senses. In the first sense the complexity concerned the general nature of matter and followed from the general relations between matter and electricity developed during the past century. Except in very special phenomena, neither free electricity nor free matter could be studied alone. The "free elements" of the chemist were no more free than they were in their compounds; in compounds the elements were combined with other elements, in the so-called free state they were chemically combined with electricity. That was fairly well understood in principle, but consistent detailed application of the principle to the study of chemical character was still lacking. The complexity in the second sense had startlingly developed from the recognition of radioactive changes and of radio-elements, non-separable by chemical means. The natural corollary was that the elements represented rather a type, the members of the type being alike in most of their properties as studied up till two decades ago, and apparently identical, therefore; but all those properties affected only the outer shell of the atom, and even the deeper-going Röntgen rays did not distinguish between them. A difference was only found in the innermost nucleus, of which radio-activity first made us aware. If the differences were ultimately electrical in character, then the chief criterion of the chemist, the atomic weight determination, would fail to distinguish between different chemical elements. That it had failed, and that there were many more elements than the possible 92 types of the periodic table, Professor Soddy showed subsequently.

In the third sense the complexity of the elements had come down to modern days from the philosophical speculations of the ancients through the alchemists of the Middle Ages and through Prout's hypothesis that all elements were built up from some primordial stuff. Radio-elements, it was now believed, were made up of helium and lead; to make further speculations was for the present probably fruitless. But the existence of isotopes, the experiments on X-rays and the scattering of matter by α particles, etc., gave a definite conception as to what constituted the difference between one element and another. One could see how gold would result from lead or mercury, though one could not control those changes, and Rutherford's nuclear atom, though only a beginning, enormously simplified the correlation of many diverse facts.

Dealing first with the element as a compound between matter and electricity, Professor Soddy remarked that Faraday's law of electrolysis, according to which a monovalent atom carried one charge, the divalent atom two charges, and so on, and his dictum that the forces of chemical affinity and electricity were the same, had really implied, though it was not understood then, the atomic theory of matter and electricity, as Helmholtz had pointed out in his Faraday lecture of 1881 to the Chemical Society. The work of Hittorf on the migration of the ions, the conclusion of Arrhenius that strong salts were dissociated in their solutions, the recognition that many reactions were instantaneous and ionic, and other facts, had familiarized the chemist with the enormous difference between the element in the charged and in the electrically neutral conditions. But the unparalleled intensity of these charges was not sufficiently appreciated; tritely to express it, Professor Soddy stated that the charge on a milligram of hydrogen ions would raise the potential of the world to 100,000 volts, and if one attempted to force free hydrogen ions into a steel bottle, the bottle would burst, by reason of the mutual repulsion of the charges, before the gas forced in would show the spectrum lines of hydrogen in a vacuum bulb. Then had come the fundamental advances as to the nature of electricity, the isolation of the electron or atom of negative electricity by J. J. Thomson, the conception of the ionic character of the discharge through gases, and the reasoning that the electron must possess inertia inversely proportionate to the diameter of the sphere on which it was concentrated leading to the all-embracing monism that all mass may be of electromagnetic origin. That had put the coping-stone on the conclusion that the elements, as apprehended in ordinary matter, were always compounds. In the "free" state they were compounds of the element in multiple atomic proportions with the electrons. The ions, the real chemically uncombined atoms, could no more exist free in quantity than could the electrons. The compound might be individual, as between atom and electron, or statistical, affecting merely the total number of the opposite charges, and the element would presumably be an insulator or conductor of electricity accordingly. The chemist had long been taught that the hydrogen molecule H_2 and the chlorine molecule Cl_2 had to dissociate into atoms H—H and Cl—Cl before they could unite to 2HCl; now he should further regard the union as comprising a decomposition or dissociation of the H atom into a positive ion and a negative electron and a combination of the latter with the chlorine atom.

One of the barriers to the understanding of these relations was the conventional idea, derived from electrostatics, that opposite electric charges neutralised one another. In atomic electricity or chemistry the state of neutrality could only apply to a point outside, remote by comparison with the diameter of the atom. We were getting back to the ideas of Berzelius; the atom of hydrogen might be strongly electro-positive and that of chlorine negative, with regard to one another, and yet each electrically neutral in the molar sense. Some day it might be possible to map out the electric fields surrounding each of the 92 types of elements. We had also to face the apparent paradox that the stronger the affinity binding the material and electrical constituents of the atom together, the weaker its combining power; in other words, that the chemical affinity was in inverse ratio to the affinity of the ion for the electrons. The case of helium was instructive; helium did not show any power at all of chemical combination, yet the atom possessed two electrons, for it was expelled without them as an α particle; one of these electrons, at any rate, was detachable by electric agencies (positive ray analysis, *e. g.*). Professor Armstrong had years ago suggested that helium and the other inert gases were really compounds of such strong affinities that they could not be decomposed; he might not think so now. Those inert gases were the nearest approach to the electrically neutral atom. In the electro-positive alkali metals and hydrogen there was one more electron than was required to satisfy the positive charge on the ion; in the halogens (chlorine) the negative charge was insufficient; hence the mutual chemical affinity between elements of these two groups. It was difficult for a chemist to realize that affinity was due to a dissociating as well as to a combining tendency. There was probably only one affinity, that between oppositely charged spheres; but the atomic charges being enormous and the ranges in chemical action minute, this affinity was colossal. What the chemist recognized as affinity was due to the relatively slight differences between the magnitude of the universal tendency of the electron to combine with matter in the case of different electrons.



The confusion between the earlier and the present views concerning the relations between matter and electricity was a further obstacle to the student. We knew negative electricity apart from matter as the electron; we knew positive electricity, apart from the electron, the hydrogen atom or the α particle (helium atom), and that was matter in the electrically uncombined condition.

Whether we spoke of positive and negative electricity, or of matter and electricity, the dualism remained. On the other hand, the theory of electromagnetic inertia was true monism; it tried to explain two things, the inertia of the electron and the inertia of matter, by the same cause. There was no reason to assume that matter minus its electron was made of the same stuff as the electron itself.

Passing to complexity in the second sense, the lecturer remarked that the new radio-active method of analysis had at once yielded three new elements from uranium: radium; polonium (changing 4,500 times more rapidly than radium), of which a ton of uranium could only contain a few milligrams; actinium, equally rare because it was in a branch line of disintegration. Polonium resembled bismuth and tellurium, but had been separated from them; actinium resembled lanthanum. The three gaseous members, the emanations of radium, actinium and thorium, found their proper places in the periodic table as extreme members of the argon family, all being of about the same atomic weight.

But further members had been discovered in the three disintegration series, the four longest-lived being radio-lead, or RaD, and ionium in the uranium series, and mesothorium I and radiothorium in the thorium series; they were not new elements, in so far as they did not possess new chemical characters, but there was no room for them in the periodic table, and they could not be separated by chemical means from the other constituents in the minerals. That latter property was not considered especially remarkable seven years ago, when the separation of the various rare earths, *e. g.*, was still very imperfect. The cases were not alike at all, however, for in the rare earths, etc., the atomic weight was the guide, and that failed in the radio-elements. In 1910, then, Professor Soddy had found mesothorium —which had been kept secret for technical reasons— to have precisely the properties of radium, and Marckwald actually published the same fact before the lecturer who, assisted by Mrs. Soddy, spent several months in further attempts to fractionate the radium-barium-mesothorium chloride obtained from the mineral thorianite. Thus in this case, and in several others, elements differing by from 2 to 4 units in atomic weight

*Reported in *Engineering*.

appeared chemically inseparable and also chemically identical. The conception of such elements, later termed isotopes, was first elaborated by the lecturer in the Chemical Society's Annual Report for 1910; the similar work of K. Fajans, to whom the conception is sometimes attributed, was published in 1913.

These views had since been corroborated by three lines of advance. Firstly, every member of the disintegration series which lived more than a minute had been chemically characterized by A. Fleck, the lecturer, and others; then sweeping generalizations had been effected in the interpretation of the periodic law; and, thirdly, a beginning had been made in the experimental study of the structure of the atom. Every case of non-separability had been confirmed by Paneth and von Hevesy, T. W. Richards and W. F. Hall, etc., by independent new methods. That might look a negative result; though thorium and ionium were inseparable, however, thorium was separable from all other elements. The spectra of isotopes had proved identical (A. S. Russell and R. Rossi over here, and the Radium Institute of Vienna), as the spectra were electronic in character, and Rutherford and Andrada had extended this identity to X-ray spectra. As regards the periodic table, an α-ray change (meaning a loss of two positive charges) sent the element two places away in the direction of diminishing mass (see diagram), and when in subsequent changes α rays were not expelled, the product frequently reverted to the chemical character of the parent, though the atomic weight was reduced by 4 units (helium = 4), making the passage across the table alternatory. The products of β ray (electrons) changes were mostly very short-lived and imperfectly characterized chemically; but the change meant a shift by one place in the opposite direction. Thus several elements were relegated to places already occupied in the table. But all those elements or products occupying the same places proved to be those which had been found to be chemically non-separable from one another and from the old occupant of the respective place; the name "isotope," indeed, indicated "the same place."

Having pointed out several of these characteristic radioactive changes,[1] Professor Soddy dwelt particularly on the ultimate disintegration product, lead. Resulting from thorium, atomic weight Th = 232 (or a little higher), by the loss of 6 α particles of mass $6 \times 4 = 24$, lead should have the at. w. Pb. = 232—24 = 208; if it resulted from uranium, at. w. U = 238, by the expulsion of 8 α particles of mass $8 \times 4 = 32$, the at. w. of lead should be Pb = 238—32 = 206. But the at. w. of common lead was 207.2.[2] Thus it looked as if lead isolated from thorium minerals should be heavier, and lead isolated from uranium metals be lighter than common lead, and that the latter should really be a mixture of the two. The geological side of the problem had been discussed at the Royal Institution by Prof. J. Joly the week before Professor Soddy's discourse.

As regards uranium minerals geologists found that the lead accumulated in them during geological time agreed with their estimate of the age of the earth. But thorium minerals seemed to contain far too little lead to accord with geological ages. Professor Soddy was not deterred, however, from attacking the thorium-lead problem. Almost all Th minerals contained U, he said, and as U changed 2.6 times as fast as Th, it was a much faster lead producer. Thorianite from Ceylon, with up to 70 per cent of ThO^2, contained also up to 30 per cent of U_3O, so that any lead found in it might be of U origin. There occurred in Ceylon, however, also thorite, a hydrated silicate of thoria, with 57 per cent of Th and only one of U; it was supposed to be free from lead, but Professor Soddy found 0.4 per cent Pb in it. He had been fortunate in securing 30 kg. of thorite. Picking the thorite out carefully from thorianite and other minerals accompanying it, he isolated 70 grammes of lead, which proved denser than ordinary lead; assuming, with Rutherford, that the atomic volumes of isotopes should be the same, the density determination yielded an atomic weight of 207.74 for this Th lead. This lead and common lead were then distilled in *vacuo* and atomic weight determinations were made after the method of Stas; these gave 207.694 and 207.20 for the two leads. On the request of Mr. Lawson—who worked in the Radium Institute of Vienna when the war broke out, and was allowed to continue his work there, though interned—Professor Soddy then sent the first portion of this thorite lead to Vienna, where O. Hönigschmid made an atomic weight determination (by the silver method), finding 207.77 ± 0.014 as the mean of eight determinations.

Simultaneously with these investigations the atomic weight of lead from different uranium ores had been determined by T. W. Richards, by M. Curie, and by Hönigschmid and Horovitz, the lowest result of the latter being 206.046, whilst lead from thorianite yielded 206.8 and from monazite 207.08. Richards and others also confirmed the conclusion that the atomic volume of isotopes was constant. There was hence no doubt that the lead from uranium was by about 1 unit lighter, and that from thorium by 1 unit heavier than common lead. The second quite independent case of isotopes differing in atomic weight concerned thorium and ionium, one of the uranium products which had disturbed the calculations on the growth of radium that Professor Soddy has been conducting for 14 years. So far the life period of ionium had seemed to be 100,000 years, against 60,000 years for uranium. Last year Miss Hitchins had definitely found radium in the 3 kg. of uranium preparation of the lecturer, and this growth was proceeding according to the square of the time, as expected. Now the ionium preparation obtained from the 30 tons of Joachimsthal pitchblende of Auer von Welsbach was almost free of thorium, and Hönigschmid and Horovitz found the atomic weight 231.51 for that ionium, while their renewed determination of the at. w. of thorium yielded Th = 232.12. If ionium were (radium + 1 α particle), as assumed, then its atomic weight should be $226 + 4 = 230$. The figures found would indicate that the ionium preparation contained 30 per cent. of ionium and 70 per cent of thorium, and would make it probable that the life period of ionium had to be raised to 150,000 years, in agreement with the determinations by Stefan Meyer (Vienna) of the numbers of α particles emitted per second by radium and by the ionium preparations respectively.

We cannot follow Professor Soddy into these intricate calculations; his estimate of the age of the earth from the consideration of thorite lead was 131,000,000 years, which is in good agreement with the geological estimate. If lead were itself unstable, it might turn into mercury by loss of an α particle, and into bismuth by loss of a β particle; of these two elements he could not detect any traces in the lead from his minerals. If, however, both an α and a β particle were expelled, thallium would result, and that was always present in small quantities. The conclusion which Professor Soddy rightly emphasized was that atomic weight determinations, already demanding supreme accuracy, will have to be conducted on new lines and be interpreted in a novel sense. If elements may be mixtures of isotopes, differing by a few units in atomic weight, atomic weight determinations lose their significance as ultimate quantitative tests of elementary character. In any case locality, geological age and the whole history of a mineral should be known, when it is to serve for such a determination. Further, Prout's thesis gains a new sense. The different elements may be multiples of one or two primordial elements. Professor Soddy suggested hydrogen and helium as possible ultimate constituents, and would ascribe the small deviations existing in the atomic weights of these constituents themselves to the manner in which the atom is constituted in accordance with the principle of mutual electromagnetic mass, as developed by Silberstein and others.

[1] Compare *Engineering*, vol. xcix, page 604, 1915.

[2] The international tables of atomic weight still gave in 1914, Pb. 207.1; the revision raised this figure to 207.2, and this alteration affects the figures to be mentioned, which differ from those previously published by Professor Soddy in his first account of 1914. In 1900, 205.36 was the accepted value for Pb.

Clearing the Way For An Advance

One of the most sensational and spectacular incidents of modern warfare is the blowing up of the strongholds of the enemy, in order to open the way for an advance of troops. Forts, in the former sense of the word, have apparently become obsolete, but to take their place many other forms of construction, which can be carried out rapidly wherever they are required, have been adopted, ranging all the way from a maze of barbed wire entanglements and bomb-proof structures, sunk below the surface of the ground and built of concrete and earth, to immense dugouts that are big enough to accommodate several hundred men. Besides these there are the immense caverns, hollowed out in the hills that have afforded a safe stronghold for large forces of men.

Some of these defensive works it has been found possible to destroy by heavy gun-fire, using high explosive shells; but many are dug in so deep below the surface that no shell is powerful enough to do material damage. In such cases the only resource is to blast them out with tons of high explosives set off beneath, and some of the military mines excavated by the Allies on the French front have been pushed to a depth of 120 feet below the surface. One of these blasting-out operations, is shown in the illustration on the first page of this issue, and such explosions are timed to take place, if possible, just before an advance is made by the troops.

It is worth while, in this connection, to note that whereas the trench defenses of the Allies are practically all of the most temporary description, with a view to being abandoned as the forces advance, those built by the Germans are of a permanent character to enable them to hold their positions, with no idea of advancing. In short, the first much boasted advance of the German armies against people entirely unprepared for war ended long ago; for two years their only hope and endeavor has been a desperate defense on an elaborately fortified line.

Economic Ship Building

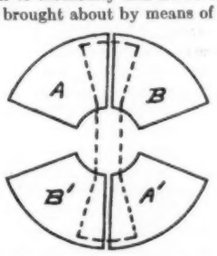
The aim of the shipowner, shipbuilder and engineer when considering a new ship is to reduce the cost and increase efficiency, so that the tendency of ship design is to this end. Reduction in cost not only means saving in first cost, but a saving in running costs and repairs, an aspect of the question sometimes overlooked. In this quest of economy, the natural place to start is at the beginning, and to a large extent must be undertaken by the shipowner himself. He must settle, with the assistance of his naval architect, the size and type of ship most suitable for his requirements. An important factor in this is the effect of the fineness of form on the freight-earning capacity of the vessel. To a large extent this must be settled for each case individually, but in many cases it has never been considered. The shipowner has been to blame for not insisting upon its consideration. As an example, we may take the case of a 9,000-ton ship of fine form having a block coefficient of .68, and a similar 9,000-ton ship of full form having a block coefficient of .8. The first will show a saving of over 3d. per ton on a voyage of 7,000 miles or, say, about £800 per annum under ordinary conditions. The first ship would cost £3,700 more to build, but this would be paid off in five years, leaving a net gain. This is merely given as an example to show that from the owner's point of view there may be "something in it."—From *The Merchant Service Review*.

A Highly Sensitive Electrometer*

By A. L. Parson, Chemical Laboratory, University of California

In this instrument the principle of working in a condition approaching instability is used to increase greatly the sensitiveness of the quadrant electrometer, which even in its ordinary form, is more sensitive than other electrometers in which this condition of instability has been employed. The box-shaped quadrants are replaced by flat sectors subtending about 70° each at the center and arranged as shown in the figure. Because of the two large gaps between A and B′, and between A′ and B, the needle hangs stably, as shown by the dotted lines, by virtue of electric forces quite apart from the torsion of the suspension. (Incidentally, this makes it possible to use a torsionless suspension or a float for the needle, which latter has been tried with some success.) If now a potential-difference is set up between AA′ and BB′ the needle is deflected, at first nearly proportionately to the potential difference, and then less and less as the large gaps are approached.

The approach to instability and hence an increase in sensitiveness is brought about by means of a mechanical



device, which on turning a micrometer screw can be made to widen the small gaps between A and B and between A′ and B′, thus making the needle less and less stable in its central symmetrical position. In this way the sensitivity which in the least sensitive condition is about 3 mm. per millivolt at a scale distance of 5 meters can be raised to as much as 60 mm. per millivolt easily, and with some care even to 150 mm. per millivolt.

A most important feature of the instrument is that, on account of the relative unimportance of the thickness of the quartz suspension, the sensitivity to potential differences is practically independent of the size of the instrument. The last model made, with a needle 1.8 cm. long, has a capacity of 9 cm., but this could without difficulty be halved by reducing the size of the instrument; and it might be halved again by omitting one end of the needle and the pair of sectors below it.

Although the sensitivity of the electrometer (with the very efficient optical system used) is theoretically great enough to detect 10^{-6} volt, it has not as yet been made steady enough to detect an isolated potential difference of less than about 3×10^{-5} volt.

*A paper presented to the National Academy of Sciences, and republished from the *Proceedings*.

Disappearing Guns for Submarines*

A Method Devised in France for Operating

By Louis Dayral, Ex-Officer of French Navy

THE announcement has been made that the Germans have constructed a new series of submarines of high tonnage (2,000 tons), armed with guns of 12 or 15 centimeters caliber and that they are getting ready to build still bigger ones to carry guns of large caliber (200, 240, or even 280 millimeters), if it proves possible.

Without insisting here upon the inconveniences incident to submarines of very high tonnage, let us merely remark that they are no novelty. Russia, in fact, had decided to build them, shortly before the war, from designs made by the Russian engineer, Schuravieff, and accepted by the Admiralty. These were for a regular submarine cruiser of 5,400 tons, armed not only with numerous torpedo tubes, but also with five rapid-fire guns of 14 centimeters mounted in a turret. The upper part of the hull, that which emerges, carries armor nine centimeters thick, as does the turret enclosing the guns. In surface navigation the displacement is 4,500 tons. To this must be added in maneuvering under water the 900 tons of water introduced into the water ballasts.

The dimensions are as follows: Length, 122 meters; width, 10.3 meters; depth of water drawn in submerging (or minimum depth of water required for complete submersion), 9.1 meters. The internal combustion motors, for surface navigation, have 18,000 horse-power. The electric motors for submarine navigation have 4,400 horse-power. They are expected to give a speed of 26 knots on the surface, and 14 knots submerged, at a minimum. The surface radius of action, at a speed of 12 knots is about 8,500 miles and 750 miles at 25 knots; submerged it is 154 miles at 8 knots and 21 miles at 14 knots. The revolving gun turret and the conning tower are telescopic and can be withdrawn into the hull.

The submarine mines carried, to be dispersed in various parts of the ocean, are stored in a rear compartment, and can be easily launched by passing through a double trap.

The engineer allows three minutes for passing from the surface to the submerged position, but this period should probably be doubled, since it would certainly require a longer time than three minutes for 900 tons of water to enter the water-ballasts.

So far as we know this boat has not yet left the stocks, but according to statements in the Berlin newspapers, the Germans seem to have used its plans to model the submarines of this type which they propose building, and some slightly reduced examples of which they already possess. In France, likewise, some time before the war, certain arrangements for the arming of submarines were devised, and patents were taken out by a great metallurgical société. These patents were registered in Germany and other foreign countries, and are therefore no secret. We read:

"At the present time (previous to 1914) submersibles make use of guns supported by carriages so constructed that the ensemble can be lowered by means of levers to the interior of a compartment, provided for this purpose between the hull and the superstructure deck.

"These arrangements involve numerous inconveniences. The compartment between hull and deck cannot be kept watertight in practice; and since on the other hand, if any projection above the deck must be avoided, the said compartment can have but limited dimensions, one is restricted to the use of guns of much reduced caliber, and carriages equally reduced in height. The present invention provides a remedy for these inconveniences, which are admitted by all experts, and presents, moreover, a series of advantages as hereinafter stated. The new arrangement secures the complete disappearance of the carriage and the gun inside the second hull, without their disturbing the crew while in that position. To this end the installation comprises a system of guides for a carriage support, or tubular port-carriage, these guides being divided into fixed elements established in a compartment of the submersible capable of being closed by a watertight hood, and into movable elements disposed in the hull and capable of being alined at will with the fixed elements or of being effaced by a raised position, towards the vault of the hull The fixed elements of the guides support the port-carriage when it is in the firing position. The mobile elements lowered and alined under the fixed elements permit the vertical descent of the carriage and gun to the interior of the boat; then they can be raised, with their hidden load, in the effaced position, horizontal or just enough inclined to clear the axial gangway of the boat. The fixed elements of the guides can also be disposed in the interior of the hull in alinement with the mobile elements when these occupy the raised position."

To sum it up, the arrangement permits the disappearance of a gun and its carriage in the interior of the submarine or submersible, and as the accompanying diagrams clearly show, is characterized by a system of slides or guides for the port-carriage which comprises vertical elements fixed in a compartment of the boat and movable elements located in the plane of the said fixed elements, below them, and capable alternately of being brought into alinement with the latter to form the lower part of the guides, at the time of the disappearance, or of being brought into the fixing position again, or of being effaced in a horizontal position in which they may serve to support the whole or a part of the hidden load. The vertical fixed guides, like the movable guides, are provided with holes for the automatic locking by spring bolts on the port-carriage, and a fixed part of the submersible is provided with very ingenious devices for the locking of the mobile guides in the raised position.

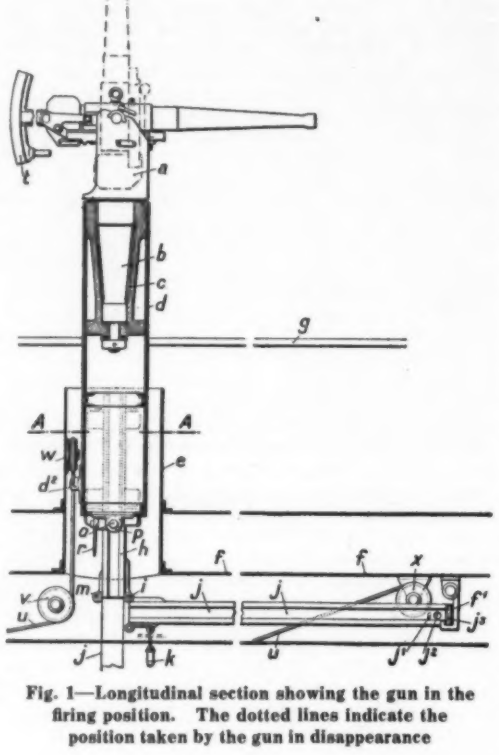


Fig. 1—Longitudinal section showing the gun in the firing position. The dotted lines indicate the position taken by the gun in disappearance

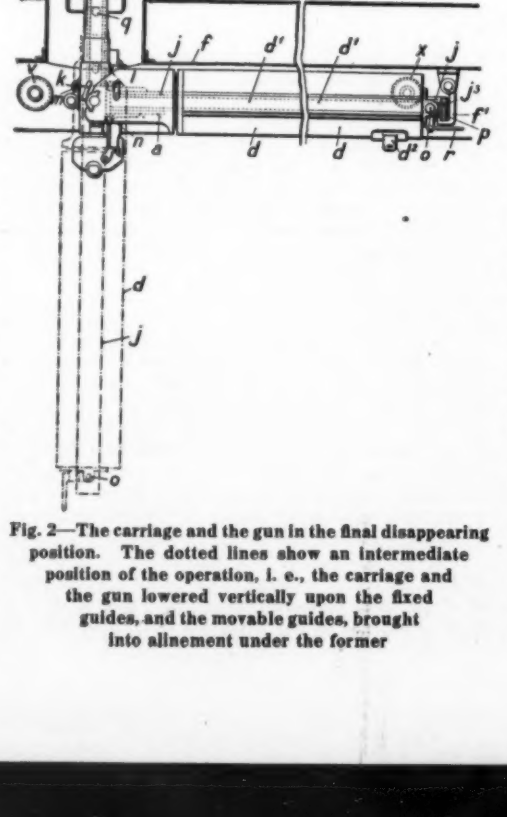


Fig. 2—The carriage and the gun in the final disappearing position. The dotted lines show an intermediate position of the operation, i. e., the carriage and the gun lowered vertically upon the fixed guides, and the movable guides, brought into alinement under the former

In the firing position (Fig. 1) the port-carriage is held upon the fixed slides by spring-bolts engaging the holes in the said slides, and which can be simultaneously withdrawn by means of a very powerful lever acting upon them by means of rods. After the retreat of the dismountable breech, the gun, on its châssis, is brought to the vertical position indicated in dotted lines in Fig. 1.

The disappearing maneuver of the gun and port-carriage is accomplished therefore entirely from the interior of the boat, by means of a cable, coming from a windlass, which can be attached by its free end to an eye of the port-carriage tube. This is the novelty of the system.

When the movable slides are brought to the vertical position, in alinement under the fixed slides, they are made immovable; then the bolt holding the port-carriage in the firing position is loosed, and the combined port-carriage and gun are allowed to descend into the position indicated by dotted lines in Fig. 2. The port-carriage resting upon a transom; at this instant the bolts automatically engage the holes in the lower part of the movable slides, which immobilizes the port-carriage upon the latter, which are then raised by the windlass in the direction desired, and brought to the horizontal position, in which they are made fast to the hull by means of a special hook.

Figs. 4 and 5 show a special and very interesting example of an arrangement in which the fixed slides are established, not in a special compartment as in the preceding, but in one of the entrance compartments of the submersible.

In this case there must be provided other fixed slides in alinement with the movable slides when the latter are in the raised position. This permits the eventual bringing of the port-carriage and the gun upon the aforesaid prolongations (Fig. 5) so as to completely clear the entrance compartment. This variant offers the advantage of not requiring a special compartment, yet it leaves in the entrance compartment a sufficiently free passage whereby the ammunition can be conveniently and rapidly brought to the gun. It should be noted that this system applies only to small guns of 37 and 47 millimeters; hence, though it dates from only a few months before the war, it is already out of style now that Germany is arming her submarines with big guns, which obliges us to do the same. It can therefore be described with no harm to the national defense. The present armament of our submarines, on the contrary, is a military secret not to be divulged.

As for the 2,000-ton boats of which we spoke at the beginning of this article, they are 85 meters long; they have four Diesel motors, giving, with 7,000 horse-power, a surface speed of 22 knots (40 kilometers) and a submerged speed of 14 knots. Their radius of action is more than 6,500 miles, *i. e.*, the round trip between Germany and America. Moreover they can carry fresh water and provisions for six or eight weeks' needs. They are armed with eight tubes for discharging 16 torpedoes, and with four turret guns of 12 or 15 centimeters, with a special arrangement for firing against airplanes and balloons. Finally, they carry 50 automatic mines to strew in the busiest zones of traffic. The upper deck is lightly armored and there are two lifeboats. The crew is composed of 50 men, with five officers, of whom two are mechanicians. The hull is double and the space between the two walls is divided into compartments, and it is said, filled with a substance which swells on contact with water. The torpedo used is the Schwartzkopf, of bronze, 0.55 meters in diameter, of remarkable accuracy, furnished with a gyroscope to secure a rectilinear trajectory; its range is 6,000 meters with a speed of 40 to 45 knots. It carries 180 kilos of T. N. T., giving it a formidable power which naught can resist. An idea of this can be found if one remembers that an automatic mine, free or anchored, which almost breaks an armored boat in two when it touches it, contains only 165 kilos of explosive. It is true that the latter strikes much lower where the ship is most vulnerable.

*From *La Science et La Vie* (Paris).

We have often been asked how many submarines Germany has in commission at present. It is hard to answer precisely, since she has never revealed the number built; and, on the other hand, the Allies do not state the number they have destroyed, which must be quite large. However, it is probable that new constructions exceed destructions, especially if the first have been speeded up, so that the flotilla grows constantly. If, as some specialists have supposed, this was made up of about 110 units, including all tonnages, at the beginning of the present year (more than a dozen for Austria), it ought now (April-May, 1917) to approximate 160 German and Austrian, of which 40 or 50 are large ones able to operate very far from their base, in the open sea, It is estimated that it would require 400, suitably provisioned, to effectively blockade the French and English Atlantic Coasts.

The increase of power of the submarine makes it a serious engine of bombardment. Doubtless it could not attack on "sea fronts," at great fortified ports; but it would be easy for it to surprise here and there undefended or ill-defended points on the coast, small ports, fishing ports, etc., and dangerously bombard little towns. Even if it had no time to submerge, because of its greater tonnage, its heavy artillery would enable it to defend itself, perhaps effectively, against armored boats, torpedo-boat destroyers.

How shall we defend ourselves against this danger which has become so grave, of the submarine of average or large tonnage, and of the torpedo? As for the latter, the present methods of defense, more or less efficacious, have been described minutely heretofore, and we need not return to them. As for the former we are still in a period of research. When the torpedo boat appeared a great menace, it was combated and annihilated by the creation of the destroyer. But this case is different, and we have as yet no submarine "destroyers." Its almost continual invisibility shields it most of the time from the patrol boats. Then there are nets and mines; but the first may be useless against the new units, which are provided it appears at the prow, with a sort of knife of very hard steel, capable of bursting a passage through the nets. And how will a net behave, no matter how solid it is, before a mass of 2,000 or 3,000 tons hurled at it with almost the speed of a railroad train?

Besides, many people have a wrong idea of the sport of fishing for submarines with nets. It must be understood that it can not be caught like a little fish. It is a very large fish that the most perfect net cannot stop.

Mines are also dangerous arms of defense. They can be anchored or they drift at a certain depth (*e. g.*,) below nine to ten meters, so as not to afford a permanent danger for surface boats. But what a lot of them it is necessary to throw in the water!

As many as possible are planted. The Germans also put them out, but they have in view the destruction of surface boats, with the submarine mine-layer which they have invented, a little thing (30 meters) which can slip around everywhere without being seen, and which drops its mines "like a fish laying its eggs," near coasts and the entrances of ports, wherever a merchantship is expected to pass. It should not be impossible for us to do as much in the vicinity of the enemy's coasts with this sort of mine-layers, and thus block the principal routes to their submarine bases.

For the merchant ship, with bulkheads too weak to resist a torpedo, there is no hope but in a gun on board. The fragile submarine fears the gun that may sink it with a single well-aimed projectile. It will fire its torpedoes, in such case, while submerging and then generally misses the target. It has been justly said that a gun (which should have a caliber of 100 or 150 millimeters) reduces the danger of being torpedoed by five-sixths, for when attacked while submerging, the submarine, almost blinded, loses five-sixth of its chances of hitting.

There is also a certain microphone arranged so it can be kept at a certain depth in the sea (it is well known that water is an admirable conductor of sound at great distances), which will reveal the approach of the submarine by the noise of the screw, thus enabling the ship to begin defensive tactics; using the Bullivant or some other net, speeding up, sailing zig-zag, changing route, etc. It can also load its guns and fire as soon as the periscope of the enemy emerges within range. There is also the seaplane, which is perhaps the arm of the future, when its flight from and return to the deck of ships can be better managed. As is well known it is able to detect the submarine sailing at a certain depth below the surface, especially in clear, smooth seas, like the Mediterranean. It can then point out the enemy by wireless or other means, or it may sink him itself, as has already occurred. But its action will be particularly effective if it is provided with a gun of the right caliber and with perfected sights.

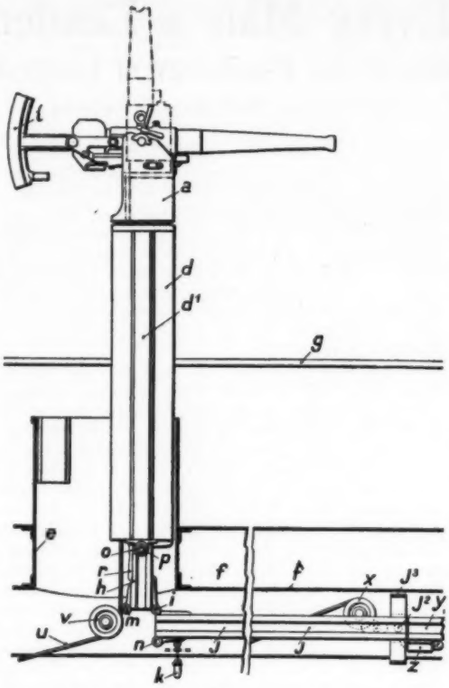


Fig 4—Variant of preceding arrangement. In this system the fixed slides are established in one of the compartments of the submersible. The gun here is in the firing position

KEY TO ILLUSTRATIONS

a, châssis of the gun provided with a central pivot *b*, lodged in a socket *c* formed in a tubular port-carriage *d*; *e*, special compartment formed by a cylindrical body starting from the watertight hulls, *f*, and ending under the deck *g*; *h*, fixed guides for two longitudinal ribs, *d*; diametrically opposite, forming an exterior projection upon the port-carriage *d*; *i*, hinges; *j*, movable guides articulated for the hinges *i*, upon the fixed cylinders *h*; *k*, movable pin engaging the lugs *m n*, borne respectively by the slides *h j*, whose apertures are shown when in alinement with each other; f^1 hook engaging the transom j^3 to retain the movable slides in the raised or horizontal position; *o*, spring bolts movable in a box *p* fixed under the tube *d*, and engaging in the holes *q*, of the fixed slides *h* to hold upon these the port-carriage *d* in the firing position; *r*, lever to withdrawn or open the bolts *o* by means of special rods; *t*, demountable butt of gun; *u*, cable to windlass; d^2, eye on tube *d* for attaching the cable; *v w*, guide pulleys; *x*, guide pulley of rope attached to a foot j^1, to maneuver the movable slides *j j*; j^2 holes in the lower part of the slides *j*, in which the bolts *o* engage in order to lock the port-carriage upon slides; *y*, movable slides extending the fixed slides (Fig. 4); *z*, supporting bolt holding movable slides fast.

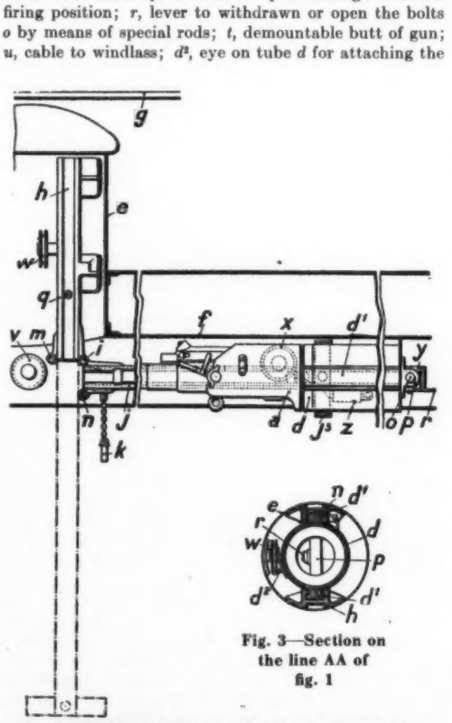


Fig. 5—Position of the gun in disappearance, i. e., withdrawn into the interior of the submarine, in the second arrangement studied

Fig. 3—Section on the line AA of fig. 1

Hydrated Lime

HYDRATED lime is a product recently put on the market to take the place of lump lime. As its name indicates, it is lime which has already been hydrated—that is, the chemical combination with the water has already taken place. It is a fine, dry, white powder which is shipped in paper or burlap bags, and which may be used for any purpose instead of lump lime.

The keeping qualities of hydrated lime have been the subject of a great deal of discussion. The original statement which was generally accepted was that hydrated lime would keep indefinitely. On this assumption, samples were tested in their ordinary commercial packages. The average of 11 samples so received showed a content of 3.77 per cent carbon dioxide, and 1 of them contained 10.09 per cent. These figures correspond, respectively, to 8.57 per cent and 22.93 per cent of calcium carbonate or inert material which had presumably been introduced by air slaking in transit. In order to investigate this matter a sample of lime was ground and screened through a 60-mesh sieve, and part of this was hydrated. A sample of the quicklime and one of the hydrated lime prepared from the quicklime and having the same fineness were exposed to the action of the air under the same conditions and were analyzed for carbon dioxide at frequent intervals. The results are as follows:

Analyses of quicklime and hydrated lime

Age of sample (days)	Percentage of carbon dioxide.	
	Quicklime.	Hydrated lime.
1	0.93	3.14
4	1.68	6.38
6	3.23	7.45
7	3.87	10.34
8	4.02	10.73
10	8.73	11.25

These figures seem to prove that hydrated lime will not keep any better than quicklime of the same fineness. The fineness is important, however, for an impervious coating of air-slaked lime will form on the top of a pile of hydrated lime and prevent access of the air to the interior of the pile.

The chief advantages to the consumer of hydrated lime are as follows: It can be handled more easily on account of its being in powder form. It will keep better than lump lime on account of its fineness. It does not require slaking, but must merely be soaked in water to prepare it for use. This saves time and labor and eliminates any danger of loss of lime due to unskilled slaking. Any unburned or overburned lime which has passed the sorter will not hydrate, and can be screened out of the finished product. Hence, hydrated lime should contain less refuse than lump lime. On the other hand, hydrated lime contains 15 to 25 per cent of water, on which the consumer must pay the freight.

Manufacturers reap several advantages from the operation of a hydrate mill. It gives them a product which can be stored, so that in case the orders for lump lime decrease unexpectedly the lime can be hydrated and stored and the kilns need not be shut down. There are several grades of stone in use which burn either to a dark-colored lime or one which falls to pieces in the kiln. Such lime can not be marketed in the lump, but will give a good quality of hydrate.

A very convenient method for testing hydrated lime is to determine its content of carbon dioxide. If properly made and stored, the proportion of carbon dioxide should be less than 1 per cent. Another method which might prove of value as a practical comparative test depends on the density of the material. Pure calcium hydroxide has a lower specific gravity than any other material which may be present in hydrated lime except water. Of 19 samples of commercial hydrated lime tested by the Bureau of Standards, 8 samples of good high-calcium hydrate showed densities between 2.15 and 2.24; 7 samples of magnesian hydrates showed densities greater than 2.38; the other 4 samples showed densities between 2.34 and 2.38. Two of these four were high-calcium hydrates containing unusually large proportions of silica; one was a high-calcium hydrate with a large proportion of unhydrated (quick) lime; and the fourth was a magnesian hydrate in which the magnesia was hydrated (because of an unusually low temperature used in burning the lime).—*Chemical News.*

Every Man a Leader

Notes on the Psychology of Leadership

By George Van Ness Dearborn

I MAINTAIN the unrealized ability of the average man. I maintain the apotheosis of the average man against all comers! He has within him, and about, all the requirements of a leader in the great world's advance. Multitudes are potential leaders who know it not! and they know it not because they still lack the fundamental principles of the dynamic relations of the mind and body. Many who think not at all of being leaders or who think they could not be, lack only the incentive and the opportunity. The opportunities are everywhere—the incentives need discussion and widespread publication. I "sing," then, the super-efficiency of the human body-and-mind as a conscious working machine, as a successful "going concern."

I cite 10,000 million nerve-units in the body; a thousand muscular units; and hundreds of glands—all integrated, all made into one organism, and under the command more or less of one will. Nothing else imaginable by the finite mind can approach it, ever, in complexity and perfection and beauty of workmanship. Nothing else so leads to leadership, and all men have, and habitually use, the requisite "machinery." The pseudo-"average" man needs to be stimulated in self-trust, and (above this even) encouraged in initiative. Most of us are not living up to, or even attempting to live up to, the broad high standards and privileges of our souls. We do not often realize what really we are—how versatile, how capable, how full of power which might well help on the world—and in so doing make ourselves men of a higher grade.

But the children! the children at any rate! Let us at least realize just this one handicap under which so many of them grow up to manhood and to womanhood. Who ever tells some of these of this marvel-machine of nerve and muscles and gland? and that it is made, (even the philosophers scarcely know how) so that it can start things up by itself—and show initiative? Not only the engine and the self-starting gear are there, but the man at the wheel as well, all in one wondrous organism. No one, sometimes, tells them this, and so they live on and on perhaps and die, never leaders in all their one life-chance—always below the ideal set by the God Himself within them. These need and from us not only encouragement, but knowledge, information, as to themselves and as to that potential leadership which is in every one of them. Encouragement, to be sure, is second in importance, but first is the simple idea, the easy but tremendous fact of latent powers. Simplicity of statement as to this, simple eloquence, repetition, reiteration, sympathy, vigorous impression, explanation—all or any of the means the psychologist, the good teacher, has at command to use in the driving-home of first and fundamental truths, these are enough.

Impress "the subconscious" with this simple bit of the wisdom of life; and the subconscious will do the rest, and never tire and never forget. Thus, or in some such way, do I plead for a much wider recognition, and earlier, in the minds of the children, the children of the rich as well as of the poor, of their respective and inherent leadership potential in its own degree in every normal girl and boy of woman born. This is a special privilege of the playground and of the gymnasium, and the good they do in this respect of personal self-respect is deep and extensive. I plead only that such counsel be made far more intensive, so that it becomes more often yet effective for leadership in the habits of the children. Some children, mostly indigent, cannot develop self-confidence nor even self-respect. It is certainly one of the essential duties, as well as privileges, of the playgrounds, and the rest, to tell them, to show them, over and over, every one, how efficient is every normal human organism. This is the indispensable start of every leadership. I try to make this notion emphatic in your minds.

Our psychology proper must be adapted to each of the two kinds of leadership: ordinary and extraordinary, or usual and unusual.

In a bit more detail, leadership in ordinary affairs involves at least four essential elements:

1. Energy of intelligence;
2. Technical understanding of situation involved;
3. The courage of optimism and of good humor; and
4. Kindliness, which is the basis of democracy.

1. That native energy of intelligence which involves, as part of itself, initiative and mastery. Resistless force of will based on understanding as deep as it is wide. This matter of initiative has much psychological and physiological interest and properly so, for in a way the concept is the personal symbol of evolution itself, as frankly and clearly it is the symbol of civilization, democracy. At initiative's stomach, so to say, is energy, energy of that two-fold one-thing what we call body and mind; at initiative's heart are the Courage and Self-confidence which are part of human personality; in initiative's brain is the Wisdom of things as they are. The Energy of body and mind; the courage of a great adventure; the wisdom based on knowledge and on insight—these are for me the essentials of initiative at least in ordinary affairs.

To this audience I need not emphasize the organic physiologic, basis of these three, Energy, Courage, Wisdom, especially Energy and Courage. But other kinds of audiences, people in general, do need to know just this relationship between Bodily Training and each of the energetic processes of the mind, the emotions in particular. Muscles and Nerves and Glands are behind these things which underlie Initiative. Just as much, however, energy and emotion and initiative lie behind and underlie the action of muscles, gland and nerve. The dependence, we may be sure, is mutual. All, in short, are but aspects of just one thing in each person, ourselves, our "souls." Let us, then, do our professional best to make our fellow men and women, college trustees as truly as "the great unwashed," understand this fundamental inter-dependence between personal initiative and strong muscles, nerves, and glands. For it now may be understood. Initiative not so based is nothing substantial in the motivity of the world; it is nothing more, nor can it be more, than an intention; a good intention if you insist, but inevitably an intention and never an effective cause at all.

2. Technical understanding of the situation concerned is of course involved in every mastery. This must be taken for granted in the psychology of leadership. Without it we have the crank, the demagogue, the "anti-"everything, the forceful individual always "agin'-the-gove'nment," always "agin" government and custom of every sort.

3. The courage of optimism and of good humor, based on appreciation of Life as a great adventure, and on the powers of the human will. Such leadership gathers ever more and more momentum, for every strong man feels at once its basal wisdom, feels inevitably that Life is too great and too deep and too meaning-full to be overcast, and thus darkened and spoiled by worry about anything whatever (unless it be one's own evil will). Optimism and good humor are assuredly an essential factor of every ordinary leadership.

4. Kindliness comes next and last. This is based largely on the continuous feeling that of all low things at once irrational and debasing, snobbery is the most despicable. Can any of you imagine a man or a woman who really understands the nature of things a snob? One might ask to dinner burglars or even a coward, but never in all one's life a snob. A leader has to have this equality-point-of-view, and determine his behavior accordingly. Autocracy is a form of snobbery! Kindliness, then, is allied to democracy! None other can remain a leader long, none who has not democratic kindliness warming his heart and brain.

These four are general factors of leadership in ordinary affairs, and are "all in the day's work," one might almost say.

Beneath these and conducting them is an intention, a purpose to be a leader; consistent; and continuous. And your intentions to be a leader must be real intentions, based in muscle and nerve-centers and in glands, in the means of ability, in your "action-system"; and deep in the mind. The good-intentions-with-which-Hell is-paved are not real intentions, but are part of the flimsy painted scenery intended for powerful appeal to the gallery full, and over-full, of unthinking and sensation-seeking people. Real good-intentions are more fit to serve in a brighter and more cheerful land! to adorn "the golden street." These scenic good-intentions are but an element of the pretense, the sham, with which so many "jolly themselves along" in an ill-adapted world, and ease themselves of pangs coming from "the conscience,"—wherever it may be. So much is a part, at least of the psychology of human mastery in general—one of the normal processes of emulation in a world already becoming, in spots, too small for its inhabitants.

But there's another kind of leadership, the other kind which sometimes all but transcends humanity at its best, wherein hero and philosopher meet, and fuse! The stoic is the stuff from which most heroes are made, that type of stoic who looks "upon the world but as the world, Horatio," a great Adventure which we both live and die. It is of this stuff that leaders and heroes are most often made. There is too much hasty and arbitrary judging of cowardice and of courage in other men and women—judging which is as false oftentimes as it is ill-advised and meddlesome. The truer wisdom is that which Will Carleton puts into his homely words,

> "Things is various and human,
> And the man ain't born of woman
> Who has got enough acumen
> To tell what's another's aims."

He, indeed, is a wise man who knows his own real motives. And who can pick out the leaders, in advance? Thinks any man, or woman with her intuition, that the hero in real-life is the splendid and widely famous handsome, dashing guardsman of Dumas's enticing tale? Can one pick the criminals out of the sidewalk-crowd on Washington Street? Can one, could you, pick the heroes by sight out of even a list of your own acquaintances and "friends?" Of course not. Only seldom may this be done in advance, for the qualities which make the leader and the hero are as deep within the man or woman or child, as deep at least as are the heart and the brain themselves! Often they rise for the first time only to meet their need. But they rise! and the world knows them at once and wonders not.

Analyzing a bit the psychology of emergency-leadership, I find seven factors important and different enough to sanction brief mention. I place the most important the latest in the list:

1. Knowledge of human nature;
2. A specific understanding of the confronting situation;
3. An appreciative moral consciousness;
4. Self-confidence;
5. Organic or bodily energy;
6. Initiative; and
7. The right combination of emotions.

Noting this list as arranged in the approximate order of importance (the least so first), one finds that the supposed factors are mainly intellectual and emotional, and the emotional elements are judged the more essential in leadership. For it is feeling that gives us the substance of our motives—and tremendous are they sometimes when oriented and guided by understanding. "Leadership without emotion" were well-nigh a contradiction in terms. Ideas lack the indispensable thrust; the stress and strain of concepts is too cold to fire a soul!

Let us take up our seven factors of leadership and see what we mean by them.

1, 2. The *de facto* leader who lacks the first two features mentioned (knowledge of human nature and understanding of the immediate conditions) is apt to end a demagogue or a clown—or both. Without these again, one is apt not to aspire to leadership at all, for it does not come within his range.

3. An appreciative moral consciousness is indispensable to leadership. Almost nothing else is mighty enough, indeed, to awaken and to vivify the deepest and strongest natures who are living the stoical life. "Only a scrap of paper"; Belgium's myriad murders and rapes and wanton childish waste; the "Lusitania"; Miss Cavell; Captain Fryatt; piracy of underseas and over-land; plotting in the guise of friendliness; the Armenian annihilation; the enslavement of deported populations; the immortal "Hymn of Hate," cursing its author forevermore; the sinking of hospital ships full of maimed soldiers; the pretense of property-rights in the Atlantic Ocean itself—the whole unbelievable and immoral ghastliness of this power-mad autocracy with which we are of its own necessity at war, has made arise a moral consciousness which would desolate the world before it could see itself again ignored or set aside!

Twenty years or more ago Archibald Lampman wrote his prophetic lines:

> "Still the tides of fight are booming
> And the barren blood is spilt;
> Still the banners are uplooming,
> And the hands are on the hilt;
> But the old world waxes wiser;
> From behind the bolted visor
> It descries at last the horror
> And the guilt.
>
> "Yet the eyes are dim, nor wholly
> Open to the golden gleam,
> And the brute surrenders slowly
> To the Godhead and the dream;
> From his cage of bar and girder,
> Still at moments mad with murder,
> Leaps the tiger, and his demon
> Rules supreme.

"One more war with fire and famine
Gathers—I can bear its cries;
And the years of Might and Mammon
Perish in a World's demise.
When the strength of man is shattered
And the powers of earth are scattered,
From beneath the ghastly ruin
Peace shall rise!"

Without a moral consciousness no man is either leader or hero. In our present national struggle against the democratic world's common enemy, the strength of the stimulus of the moral consciousness should make leaders of us all! With such a moral consciousness, the life of men and women is the most magnificent Adventure that could ever be conceived, and Leadership of some sort becomes the natural, the ordinary thing.

4. Self-confidence as a condition of leadership means what it says, but greatly more than it says. One trusts his well-tried muscles and nerves because multiform experience has shown him their versatility and their power. But also he realizes that beyond dispute his abilities have no definitely assignable limit over his environment of men and of things, of time and space and circumstance, which often to another are quite out of reach even, to say nothing of his being their master. And the inborn genius that makes a man or child trust himself, makes him, just as certainly, trust the powers of others, since mind is mind and much alike in whatever organism it may be materialized. Thus a characteristic of a true leader is trustworthy ability to pick others who shall be leaders, too. But meanwhile he trusts himself—and partly because he does so, seldom is he disappointed. As has been suggested already (repetition is a valuable pedagogic method) the average child or young person really needs nothing whatever more than he needs to learn how capable his organism is.

5 and 6. Bodily energy and initiative determine leadership in active affairs somewhat as gasoline determines your prompt return home from your week-end in the country. You may have a good time without it—but you'll never "arrive!" Here come we back directly to Physical Education, to that self-respect which understands, intuition, if you will, that however hard it is to comprehend the relations of mind and body, in some way the "organism" and the "mind" are certainly but aspects of a something which is neither, but which eternally is OURSELVES.

We can no longer dare, then, having this knowledge, to neglect our bodies, not so much (if I may not be misunderstood?) because our bodies are "God's temples," as we used to hear, as because they are our own temples—in which mere Life itself, when normal, is almost prayer. Does some famed poet say, "The undevout astronomer is mad?" say I: Every man who really strives to understand his own wonderful body and its relations to the energies of this wondrous world and yet is not devout in the only real sense of that term, such has not the intelligence to be mad:—idiots cannot go insane.

I am strenuous, then, for the widespread publication of the sanctions of the flesh, of the philosophy of the body, to the end that after the years are gone and others come, all men and women in general may appreciate this marvel of life—of muscles and nerve and gland—which is loaned them for the cultivation of their leadership! For leadership is its finest apotheosis, the star-reaching climax of its unimaginable intricacy.

7. But, lastly, the emotions, the right set of emotions, if you please, condition emergency leadership, and alone make the hero, leader of men, a reality, something more than an optimistic dream. Never in the history of this world, since at least the days of Caligula, and Nero, and Ivan the Terrible, have the leadership-emotions been more ready, more natural, more inevitable in the soul of the strong man, zealous for the highest dignity of mankind. And it is emotion and emotion alone that supplies the energy for man's action.

What more would you have? What set of energetic emotions could out-"move" these? Surprise; Indignation; Scorn; Disgust; Anger; Pity; Sympathy; Fear; Hope—some of the strongest emotions mind can feel—crowd in unruly eagerness into the forefront of our preparedness for leadership. Emotions such as these, indeed for the most part, these very emotions, will save the world once more—for millions with guns or dollars or busy hands, will show themselves leaders if not of others then certainly of themselves—and Civilization, so long, even in this twentieth century, dragged backward on "the road to yesterday," will again press onward toward its certain goal of universal brotherhood.

And Kipling's waking lines:

"In the gates of death rejoice!
We see and hold the good—
Bear witness, Earth we have made our choice,
For freedom's brotherhood.

"Then praise the Lord most high,
Whose strength has saved us whole,
Who bade us choose that the flesh should die,
And not the living soul!"

But, gentlemen, I was not asked here to urge you to enlistment in this vast World-War; rather to talk on the Pyschology of Leadership. I would close, then, and properly, with a resumé of the psychologic points I have suggested:

SUMMARY

Every normal human being is potentially a leader; and every one should be made to realize it while yet he or she is a child. This is an educational duty.

Intelligence of course underlies ability in leadership.

Initiative, a personal symbol of Evolution, has as a stomach bodily energy, as heart, courage and self-trust; as brain the wisdom of insight.

The public needs to understand the sanctions of the flesh.

Kindliness and optimistic good humor may not be overlooked, from snobbery a whole world apart.

The intention to be a leader must be a flesh-and-blood intention.

Heroes are stoics to whom Life is an Adventure, but always a noble adventure.

Knowledge of "human" nature and of the specific situation are essential.

The Moral Consciousness is always involved in leadership even as is oxygen in our physical living.

It is emotion that leads the world around.

He who can lead himself can lead others also.

Bodily training underlies the indispensable vigor self-confidence, and initiative of every leadership.

New Colorants from Methylene Blue for Microscopic Specimens

PREVIOUS to the present war Germany had a practical monopoly of the dyes and the drugs derived from coal tar. In the last three years necessity has forced America, England and France to call on their chemists to make good the keenly felt lack of these products, and with so much success in many lines that it is freely predicted that Germany will find it exceedingly difficult, if not, indeed, impossible, to regain the commercial empire thus wrested from her grasp.

Among the most important of these chemical products are the stains or colorants used to tint microscopic specimens of various sorts. These have become practically indispensable to the scientist in certain lines of research. It is encouraging to hear that at one of the April sessions of the French Academy of Sciences new substitutes for two of these colorants were described. The stains in question are derivatives of methylene blue, and are known as methylene violet and methylene azure. The investigators, Messrs. Tribondeau and Dubreuil, state the results of their experiments in the following terms:

There are many processes by means of which there may be made to appear in a solution of methylene blue two derivatives which are extremely useful in staining microscopic specimens: methylene violet and methylene azure. All these processes are based upon the intervention of an alkaline reagent: silver oxide for Borrel blue, potassium carbonate for the polychrome blue of Unna, borate of sodium for Manson blue, etc. But until now no one has published a method for obtaining the azure and the violet of methylene in an isolated state.

Hence we have remained tributary for these products and the coloring solutions derived from them to the German firms to which Giemsa confided his secret technique of the manufacture of azure.

We have undertaken to liberate our French laboratories from this subjection, and we have succeeded in accomplishing the manufacture of the violet and the azure of methylene in a very simple manner.

We start with a one per cent solution in distilled water of medicinal methylene (of French manufacture). To this we add five to ten per cent of liquid ammonia. After mixing in a glass flask this is heated to boiling in a water bath. An abundant precipitate is formed. This is filtered while hot on folded paper and the filtrate is placed in a large photographic tray to evaporate, in an oven at a temperature of 37° to 40° C. The residual substance, collected by scraping and then reduced to powder is practically pure methylene violet.

A small part of the precipitate is found upon the filter, but the larger part remains adherent to the walls of the flask. It is allowed to remain therein in filtered air with the flask uncorked for at least 24 hours, preferably in the ice-box to prevent the evaporation of the impregnating liquid. Under these conditions the precipitate acquires a blue black color of increasing intensity.

When this transformation is completed we recover it with distilled water in which it now readily dissolves. It is then filtered and this new filtrate is treated as was the preceding. Thus a second powder is obtained which is methylene azure.

Proper manipulation should finally give nearly equal quantities of ammoniacal azure powder and violet powder.

These powders we have utilized in the preparation of three coloring solutions: 1. An aqueous solution of azure. 2. An aqueous solution of azure and violet which we call ammoniacal *polychrome blue*. 3. A glycerinated-alcoholic solution of azure and eosine, analogous to Giemsa's mixture, to which we propose to give the abbreviated name of *azéo*.

The aqueous solution of azure is made with 1 gram of ammoniacal azure in 100 cubic centimeters of distilled water. We use this for the coloring of fresh organic substances or liquids, between slide plates. It is sufficient to mingle a drop of the colorant with a drop of the substance to be examined; cover with a lamella; seal; examine by artificial light. The coloration is progressive, then regressive.

We thus obtain excellent preparations of the cells contained in the liquids of pathologic effusions, and of the amoeba of dysenteric mucus. In general, results vary with the chemical reaction of the substances studied.

The ammoniacal polychrome blue is a mixture of the aqueous solutions of ammoniacal violet and azure, each one per cent. The best proportion of the two components is ordinarily one part of the blue solution for every three parts of the violet solution; it is determined by trial, taking for a criterion the colorations of sputum. In our daily practice we have substituted this mixed blue for phenic thionine and for Unna blue. It has the advantage of not undergoing alteration as do these. It is suitable for all the simple colorations of microbes, but it is peculiarly valuable, by reason of its specific and remarkable metachromasia, for the examination of specimens of sputum and of pathologic organic liquids (pus, urethral secretions and those of buccal ulcers, the residation of the centrifugation of the pleural liquid and of the cephalo-rachidien liquid, etc.) The method of using is very simple. In the case of specimens of sputum the technique of Besançon and Jong (with Unna blue) is very suitable, provided that fixation is by alcohol and not by chromic acid. In the case of the other rubbings we fix by means of alcohol, color for a length of time ranging from thirty seconds to one minute, wash and dry; it is sometimes useful to differentiate rapidly with absolute alcohol. Examination by artificial light is indispensable.

Azéo is manufactured by the aid of two solutions, one of ammoniacal azure, the other of French eosine, one per cent in absolute ethyl alcohol, one fourth glycerinated (alcohol 75 per cent, glycerine 25 per cent). The solution of the blue is poured little by little into the solution of the eosine until the one is neutralized by the other, which requires a mixture of approximately equal parts of the two solutions. This mixture is allowed to stand for several days, so that the combination of azure and eosine may have all the time required to complete the combination. We then add an excess of the glycerinated alcoholic solution of azure (about two parts in eight parts of the aforesaid mixture). The azéo is used in baths like the Giemsa, which permits us to color several preparations at the same time in a single dish. The dilution (on the average one drop per cubic centimeter of distilled water), the periods of coloration, the methods of employment, and the various kinds of utilization of the celebrated German colorant are all applicable, and yield results equally good, if not superior.

The fixation of the preparations to be colored can be made as for the Giemsa, either by means of absolute alcohol or by the colorant itself diluted with its own volume of absolute alcohol. But the best plan is to fix with biecosinate[1]; we thus realize the panoptic method of Pappenheim, but with biecosinate instead of the May-Grünwald mixture, and with azéo in place of Giemsa, that is, by means of two French colorants.

Ancient Rock Carvings in Sweden

AT Leonardsberg, four kilometers from Norrköping, Sweden, there recently have been discovered and cleaned from the surrounding earth a number of rock-carvings, both large and small. One of them shows a row of human figures, among others women with children, men bearing shields, horses, and two other quadrupeds with curious head ornaments. Another interesting rock-carving has been discovered in Biskopskulla parish in Upland. Six previous carvings were known from this district, but the present one is the representation of a ship of a type hitherto unknown there, since it is not merely outlined but carved on the rock in low relief. About one meter long, it represents one of the so-called dragon ships, and belongs to the oldest group of such monuments of the Bronze age, a conclusion confirmed by its height of 32.5 meters above sea-level.—*Nature*.

[1] L. Tribondeau, W. Fichet, and J. Dubreuil, Process of Coloring Organic Liquids and their Parasites (C. R. Soc. Biol.). April 1, 1916.

Artificial fertilization of the carnations

The plants must be sprayed carefully

"Iron-Stemmed" Carnations

Growing Improved Varieties in Paris

By Jaques Boyer

THOUGH the cultivation of carnations is an art long practised, the present marked improvement in it is of very recent date. While innumerable varieties showing the widest range of color have been offered for many years, they have shared the common defect of a stalk so frail as to be unable to support the flower without bracing. Now, thanks to selective breeding, M. Vacherot and other French horticulturists have succeeded in producing a new and robust breed known as "iron-stemmed," whose richly colored double blossoms now compete in the French markets with roses and lilies. Large-blossomed carnations are produced at present by one of three methods; from seed, by layering, or by cuttings. Seed sowing is resorted to only when new varieties, more perfect in form or more pleasing in color, are desired. In such case recourse is had to artificial fecundation, *i. e.*, the pollen of one flower is transferred to the pistil of another, magnificent plants being thus obtained.

Layering is employed in the case of certain varieties which strike root with difficulty. But the most usual method of growing is by cuttings. In the climate of Paris these are made in July or August in a cold atmosphere; they are then potted and placed in hothouses for the winter; or otherwise they are made in a warm atmosphere from January to March and repotted in April or May. The cuttings are taken from plants in full flower at the axil of the flower-bearing branches, the most vigorous and healthy specimens being chosen. During the summer the carnations which have struck root are kept very clean and are provided with props. When it is desired to force them they are placed in hothouses heated to a temperature of 12 to 15 degrees Centigrade as early as October, and are aired as frequently and as thoroughly as possible.

Watering of the plants should be done separately and very cautiously. Experienced growers also advise "disbudding," which consists in suppressing one or more buds on the flower stalk for the benefit of the terminal bud; the effect of this is the production of flowers which are larger, better shaped, and more lasting. Certain delicate precautions on the part of the horticulturist are also necessary. From time to time leaves are plucked off, stamens which might cause the corolla to decay are removed, the hot-houses are kept heated regularly, the plants are frequently aired, etc. By such measures the florist can count on a succession of blossoms through the winter.

Before delivering them to customers workwomen make the toilet of the gathered carnations, whose stalk they fasten to a little stick. For this they make use of a primitive apparatus shown in one of our photographs. This consists of three vertical uprights made of wood and fastened to a horizontal board, and connected with each other by a lath running between. The uprights bear three nails on which the stem of the carnation and the wooden stick are placed, which facilitates handling. The carnations called "Colossus" from the firm of M. Vacherot at Boissy-Saint-Léger (Seine-et-Oise) have blossoms measuring as much as 14 centimeters (about 5½ inches) and are as much sought for as roses.

Iris Perfume Industry in France

The iris root (commonly called "orris root") is a product which is largely cultivated in the South of France for use in the perfume industry, and especially in the southeastern coast region. According to an account of this industry and the most recent methods employed, which is given by M. X. Faucillon, the root of the plant is first peeled and washed, then dried in the sun and stored in a dry place. The old process for extracting the perfume consisted in drying and pulverizing the root, and the powder undergoes two processes, it being either distilled to obtain the essence or macerated in pure alcohol so as to obtain an extract. Both these products are used in the preparation of toilet water or iris extracts. Distillation is carried out by a steam process but this is a long and difficult one, and the apparatus may be rapidly deteriorated by the fatty acids, coming over from the still, for these attack the metal when hot. In fact a considerable heat must be given to the water surrounding the receiver so as to keep the oily essence in the liquid state, for in the cold it is semi-solid and would thus clog up the pipes. In spite of its

Picking the flowers

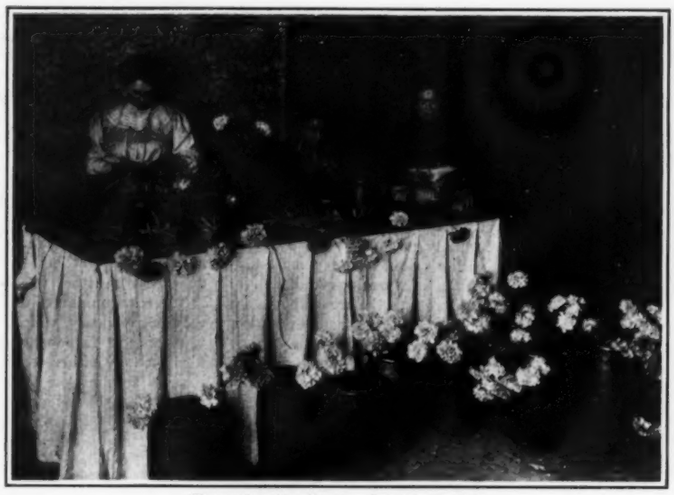
drawbacks, this process is not entirely abandoned, and the vaseline-like iris essence is a regular commercial product. However a more efficient method is now being put in use, and it is based on the good solubility of essential oils in coal-oil derivatives such as rectified gasoline or ether or in bisulfide of carbon, ethyl chloride, etc. The powder is washed repeatedly with the extracting liquid, and the latter is placed in an alembic or similar apparatus so as to drive off the liquid by a vacuum process or by heating. This leaves a resinous substance which is removed and purified by alcohol, and in this way the resins and wax are eliminated, for these have no value. After treatment by alcohol and evaporation, there remains a resinoid or varnish-like extract of iris which has a strong odor, this representing in fact a highly concentrated infusion of iris, which product can be used commercially in this state. However it can also be rectified still further, and there is obtained "irone" or absolute essential oil of iris, and this is a better industrial product than any of the preceding. However, the process just mentioned is not without certain drawbacks, for the apparatus is expensive and there is also danger of fire when handling such large quantities of inflammable liquids. This led to a search for new solvents such as dichlorethylene and trichlorethylene, which have the same advantages as gasoline but are not inflammable. In this new process the powder is simply stirred up with about its own bulk of the liquid, and the paste is put in a rapid filter pump. The powder is quickly dried, and the liquid is evaporated so as to obtain a pure resin of iris which is then treated by alcohol, and after filtering, this gives a concentrated infusion of iris. In this method all the perfume is not removed from the powder, and it still has an industrial value as such, being of a whiter and more desirable color for certain powder mixtures. The present method is quite an improvement in the process of extracting the iris essence, and it could be used to advantage on a wider scale for the extraction of perfume substance from a great number of plants.

Deterioration of Refractory Materials in the Iron and Steel Industries

THE chief cause of the deterioration of bricks in open-hearth furnaces is the combination of basic flue-dust and volatilized oxides with the material of the bricks. The intensity of the bombardment by dust particles is greatest in the center of the roof and least in the middle of the furnace. The slag formed by the action of the dust on the bricks forming the roof seems unable to penetrate them, so that permeability and porosity are not so serious as is often supposed. It has a better opportunity of penetrating the bricks forming the lower part of the walls. The "cutting action" of flames, the rapid movements due to sudden changes in temperature, and particles of slag shot up from the molten charge also assist in the destruction of the bricks. The deterioration of regenerator bricks is mainly of a chemical nature, due to the fluxing action of the basic dust derived from the charges and slag, and carried over from the body of the furnace.

The deterioration of the bricks used in lining blast furnaces and cupolas varies with their position. Near the top of the furnace the chief cause is the abrasion due to fresh charges of ore and fuel, but within the shaft the brickwork is largely replaced by a black porous "scar" of graphite. At the hearth, chemical action between the contents of the furnace and the bricks is the chief cause of the destruction of the latter. Bricks free from iron oxide, and the exercise of care to prevent the formation of this oxide, are recommended. Deterioration by dust may be partially prevented by keeping the amount of dust produced (especially when charging) as low as possible, by suppressing the dust before it reaches the regenerators, and possibly by using neutral or basic bricks made of bauxite, serpentine, steatite, limestone, dolomite, and magnesian limestone, though the application of these materials opens up a wide field of research. To resist destruction in blast-furnaces and cupolas, the composition and texture of the bricks must be adjusted, and bricks used which are free from iron oxide. Abrasion is only important in blast furnaces and cupolas, and in these it is increased by the formation of a friable scar and by careless charging. Differential movements tend to general disintegration and open up cracks and joints into which corrosive slags and vapors may penetrate. Other factors concerned are workmanship, regulation of temperature, adjustment of tie-rods, variation in shape and size of firebricks, and the use of damaged bricks. Note in *J. Soc. Chem. Ind.* on a paper by H. B. CRONSHAW in *Trans. Faradary Soc.*

Removing unnecessary leaves and stamens



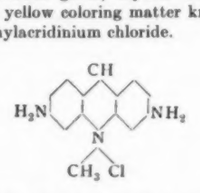
Preparing the flowers for the market

New Antiseptics

NOT the least important feature of the present war is the interest which has been concentrated on the effective treatment of septic wounds. Attention has already been directed to the use of the hypochlorite solutions of Dakin and Lorraine Smith, and to that of chloramine-T of Dakin, Cohen, Daufresne, and Kenyon. These substances, while they possess strong bactericidal properties, have little or no irritant or toxic action in antiseptic strength, and have in consequence found very general and successful application.

The defects of most antiseptics lie in the fact that, while they act chemically on proteins and so destroy bacteria, they also affect the serum, which has itself powerful antiseptic properties. This probably explains the large reduction in bactericidal action of most antiseptics in presence of serum. Furthermore, most antiseptics inhibit phagocytosis and so deprive the body of one of its most important weapons in combating local infection. An ideal antiseptic should therefore combine powerful bactericidal action along with the absence of deleterious effect on phagocytosis or on the nature of the serum. It should further be without irritant or toxic action, while stimulating healthy granulation. The latest contribution to the subject, by Messrs. Browning, Kennaway, and Thornton, and Miss Gulbrausen, of the Bland-Sutton Institute of Pathology of the Middlesex Hospital, is embodied in a report to the Medical Research Committee. It was published in the *British Medical Journal* of January 20.

Among the substances which the authors have examined are a number of triphenylmethane dyes (malachite green, brilliant green, crystal violet, and ethyl violet) and the yellow coloring matter known as flavine or diaminomethylacridinium chloride.



The latter was originally tried by Ehrlich on trypanosome infections, and was found to have a very marked therapeutic effect.

The authors claim that whereas the bactericidal action of flavine is stimulated by the presence of serum (*Staphylococcus aureus* is killed in dilution of 1:20,000 in water, but in 1:200,000 in serum), its power of inhibiting phagocytosis is not high, a concentration of 1:500, as compared with 1:625 for chloramine-T, 1:13 for eusol, and 1:9 for Dakin's solution, being required. For a true comparison, however, it is necessary to determine the relation of the bactericidal action (*i. e.* the minimum strength of solution required to kill the bacteria) to the phagocytosis action (*i. e.* the strength of antiseptic required to reduce the number of leucocytes to half that of the pure serum control), and this ratio, which the authors call the therapeutic coefficient, is much higher than that given by any of the older antiseptics or the dyes referred to. The irritating effect was compared by placing three or four drops of the solution on the conjunctiva (rabbit) for three minutes. Flavine produced no effect in a concentration of 1:200, mercuric chloride 1:500, and chloramine-T 1:25. It thus appears that though flavine does not compare very favorably with chloramine-T in its irritant action, or with the absolute values of the hypochlorites in phagocytosis, its interest appears to lie in its exceptional bactericidal properties, and more especially in the enhanced effect said to be produced by the presence of serum.

The value of the antiseptic seems to center round this fact, and it will be interesting to learn what special property attaches to flavine whereby it is able to destroy bactria, while not only leaving untouched, but materially activating the antiseptic properties of serum.

In summarizing their results, the authors claim that flavine has been found to possess extremely powerful bactericidal and antiseptic properties, which are enhanced rather than diminished by admixture with serum; that in presence of serum flavine is the most potent bactericide of all those investigated for both Staphylococcus and *B. coli*, and it is equally efficient for the enterococcus and for anaerobes, such as *B. oedematis maligni;* that flavine, in relation to its bactericidal powder, is very much less detrimental to the process of phagocytosis and less harmful to the tissues than the other substances; hence much higher effective concentrations can be employed without damaging the tissues or interfering with the natural defensive mechanisms. —*Nature.*

An Emergency Ration*

THE problem of rationing the soldier is of the utmost importance not merely for the purpose of preserving his physical health but of conserving his military effectiveness. Regardless of what the civil population subsists upon, the rationing of the soldier must not be reduced so as to curtail his food requirements.

It often times becomes necessary to send in advance scouting parties for whom adequate food supplies cannot be prepared to be carried by them. To meet such military exigencies an emergency ration is essential.

As Vedder has pointed out in the *Military Surgeon*, June, 1917, an emergency ration must be balanced and possess a reasonable energy value and tissue building power. Palatability must not be sacrificed. Its bulk must be minimal in order to prevent the ration from serving as a drag upon the soldier, already weighed down by his essential military appurtenances. The food must be of such a character that it will not readily deteriorate, while at the same time it must be cheap and readily purchasable.

Vedder has suggested, as an emergency ration, ten ounces of hardtack and six ounces of sweet chocolate. The total weight of the ration is one pound, while it supplies approximately 2,100 calories of which 180 calories arise from protein sources. A man resting in bed requires 1,800 calories per day to satisfy the normal heat and energy requirements of bodily function. According to Chittenden, on a low protein diet, 250 calories from protein are provided with a total of 2,854 calories for the 24 hours. The haversack ration as at present constituted supplies approximately 4,500 calories per day with 460 calories arising from protein elements. This ration naturally provides the due and proper amount indicated for soldiers engaged in hard work.

The emergency ration suggested is not liberal in character and in fact materially reduces the total food required for the soldier, but this is merely for emergent purposes and should not actually interfere to a great extent with the physical health of the consumer providing that it is utilized merely in emergencies. It is patent that the bulk is not excessive and that the foods suggested are cheap, generally available, palatable and resistant to deterioration. There is a reasonable distribution of protein, fats and carbohydrates which maintains the balance of the ration while its general digestibility is beyond question. While vitamines form an essential part of foods to be supplied for long periods of time the low vitamine content of the ration is a negligible element considering that the ration is designed for very temporary occasional use. Under the circumstances the suggested ration should meet with favor and at least be placed on trial for the purpose indicated.

No military problem is of greater significance and importance than the complex and serious questions involved in keeping the lines of communication open so that the stomach of the soldier may receive the comfort and aid which are so essential for his welfare. Provision must always be made for the breaking down of a system, no matter how perfect it may be theoretically. To meet such contingencies the haversack ration has been devised, but this needs to be supplemented by a food which is practical, nutritious and digestible and that may be carried for long periods of time without undergoing the deterioration to which the haversack ration is subject.

The general food value of sweet chocolate has not been thoroughly appreciated. The fact that six ounces of sweet chocolate provides 823 calories attests its high nutritive value and recommends it as a valuable foodstuff for the service of the civil population as well as those engaged in military duties. To be sure hardtack requires mastication, but hunger provides sufficient impetus to guarantee that it will be properly prepared for the action of the digestive fluids. The high carbohydrate content makes thorough insalivation of pronounced value as the first stage in its digestion.

Taking it all in all this combination of hardtack and sweet chocolate commends itself as being particularly well adapted to the needs of the soldier and the requirements of an emergency ration.

*From *American Medicine.*

The "Spin" in Aeroplane Flying

A SPIN is the extraordinary turning movement that some machines only too readily take up after being stalled on a turn or being turned too flatly even with plenty of flying speed. This is due to the machine suddenly meeting the air a great deal out of the parallel with its longitudinal axis, either through side-slipping, skidding, or yawing in the air.

Having had more than one involuntary spin, but having been fortunate enough to have sufficient height to get out again, I feel the matter is not to be treated too lightly. The position a machine assumes in a spin is a rapidly revolving side-slip or a fairly steep spiral dive, with this rather serious drawback, that the more one tries to pull it up by means of the elevator, the faster it spins.

No matter how high one is, if one persists in trying to pull it out in a normal way, it will remain out of control, because the elevator has now become the rudder, and instead of pulling it out, increases the speed of turning If the controls are abandoned the machine will come out its own accord, but personally I have always found the best and quickest remedy for spins is to straighten the rudder and shove the joy-stick forward; a clean nose-dive will then result, out of which the machine can be pulled.

I think, in the matter of spins, prevention is better than cure, and it is up to the designers to see that their machine is of the non-spinning type, as, however clever and quick the pilot may be in applying his pet remedy, he may not have height enough to do so, and the results are usually disastrous.—From a lecture by CAPTAIN B. C. HUCKS, R.F.C., before the Aeronautical Society, London.

Chemical Reactions of Iron Smelting*

A Review of Processes as Carried on Today

By Walther Mathesius[1]

THROUGHOUT the Middle Ages, and as late as the first half of the nineteenth century, blast furnaces were operated the world over with the utmost of secrecy. Those skilled in the art carefully guarded their knowledge, surrounding their work with a veil of mystery and handing it down from father to son as a precious tradition.

There are still many adherents to the creed that blast furnace progress must be brought about through practice, leaving it to science to afterwards explain the "whys and wherefores." Men of this type overlook the fact that, since the introduction of hot blast, when explanations were sadly lacking for the startling improvement wrought thereby, science has made gigantic strides to close the gap between actual results and their theoretical understanding. As the day draws near when the scientist will wring from the blast furnace his last mystery and will mark it down with mathematic exactness, the theory of the blast-furnace process demands of the furnace operator more respect and attention than ever before. While he may not care to follow all the intricate lanes of research and experimentation that have led to the present knowledge, he should have a thorough understanding of the process with which he deals, and it is from his standpoint that I intend to review the reactions of iron smelting as carried on in the blast furnace of today.

PHYSICAL AND CHEMICAL DUTIES

The task of the blast furnace, while performed as one continuous and interlocking process, may be divided into physical and chemical duties. Among the former the principal items are:

The drying and preheating of the burden materials.

The melting and superheating of the resultant iron and slag.

The chemical duties comprise chiefly the following:

The calcination of the carbonates.

The reduction of the metallic oxides of the ore burden.

The relative importance of the physical and chemical work may be best judged by comparing the amount of energy consumed by each. This can readily be calculated by establishing a heat balance.

An average taken from a number of such calculations covering modern operations shows that, of the total heat introduced into a blast furnace and generated therein, approximately 25 per cent is sufficient to take care of the above-mentioned physical duties, while the chemical reactions require about 60 per cent of the total, the balance being absorbed in radiation losses and heat escaping with the gases. These figures gain particular interest when considering that it is the physical part of the blast furnace work only that is immediately accessible to observation and measurement. Any improvement or deterioration in the chemical work must affect the furnace efficiency as a whole to more than double the extent than would a change of equal magnitude in the physical or melting operation. Economy in the performance of the chemical reactions is, therefore, of prime importance to the blast furnace man.

From the total amount of coke which is charged into the blast furnace, a certain percentage is always carried out by the furnace gases as coke dust, and another portion is dissolved by the pig iron. At plants using similar raw materials, and under normal operating conditions, the sum of these two items varies only within narrow limits and amounts to a small percentage of the total. It does not decidedly influence the general efficiency of the furnace operation. The fuel consumption depends almost exclusively on the mode of gasification and utilization of the remaining major portion of the carbon in the coke. The possibilities in this respect are:

1. The carbon, having passed downward through the furnace stack, reaches the hearth and is gasified there either by:
   (a) Combining with the oxygen of the blast at the tuyeres, or
   (b) Combining with the oxygen of metallic oxides (direct reduction).
2. The carbon does not reach the hearth, but is gasified above the hearth by reacting with the CO_2 of the furnace gases (premature combustion).

The reactions classed under 1 are normal operating necessities. Reaction (a) creates heat and reducing gas (CO); reaction (b), while consuming heat, furnishes reducing gas and pig-iron product. As long as their sum total and their relative proportion remain within proper limits, these reactions must be classed as desirable, while an excess of either one is superfluous and detrimental.

The reaction named under 2 produces, at a loss of heat, reducing gas only, which, if at all required in the operation of the furnace, could be more advantageously furnished by either reaction 1 (a) or 1 (b). The premature combustion of carbon must, therefore, in all cases be considered a detrimental reaction.

All three of these reactions have one thing in common. They produce carbon-monoxide, the agent by means of which by far the largest portion of the metallic oxides in the furnace burden is reduced to metal. This process, for which the equation $Fe_2O_3+3CO=2Fe+3CO_2$ may serve as an example, is known as "indirect reduction." Its economy is in a large measure responsible for the remarkable efficiency of the blast furnace, which to the present day has not been surpassed by any other metallurgical process.

INDIRECT AND DIRECT REDUCTION

From a standpoint of economy, the indirect reduction is more desirable than the direct reduction. The latter is economically permissible only under the following conditions: First, where indirect reduction cannot take place—for instance, when reducing oxides are not accessible to furnace gases; and, second, in case the combustion of carbon by the oxygen of the blast at the tuyeres does not furnish sufficient carbon monoxide with which to properly take care of the indirect reduction.

Direct reduction, as mentioned first, takes place in every furnace and is a function of the composition of the iron; in other words, the percentage of silicon, phosphorus, manganese, etc., to be reduced and of the percentage of burden materials, the metallic contents of which are for physical or chemical reasons not accessible to the reducing action of the furnace gases. With these conditions given, this phase of direct reduction can be considered as practically constant.

The other case of direct reduction, which is due to scarcity of CO from combustion at the tuyeres, is most likely to be incurred where furnaces are burdened with ores that are easily reduced, and where such furnaces are operated at a fast rate of driving, with high-blast temperatures. Under such conditions, direct reduction will take place to a greater extent the lower the percentage of silicon is in the pig iron. Modern Mesaba practice on basic iron is a good exmaple.

The extent to which the various reactions will perform within the blast furnace depends in a large measure upon the reacting speed of which they are capable. The speed of any chemical reaction decreases the closer the relative quantities of the reacting and resulting substances approach the status of equilibrium. Therefore, various reactions will, within the limited time available in the blast furnace, take place to a larger extent the farther away the relative quantities remain from the status of equilibrium. In other words, in order to be reducing to a degree sufficient for actual practice, the furnace gases must be richer in CO than would be expected from the experimentally determined diagram of Baur and Glaesner.

Thus the possibility of a modern furnace being insufficiently supplied with carbon monoxide through the combustion of carbon at the tuyeres is by no means remote. It is incurred particularly where, with easily reduced ores, high blast temperatures are used, because with higher blast heat the generation of the necessary quantity of heat in the hearth requires less carbon. Theoretically, and keeping strictly within the boundaries of Gruner's theory of the ideal working of a blast furnace, this condition should be remedied by lowering the blast temperature and burning more carbon at the tuyeres. Otherwise, ore must reach the hearth without being properly reduced by the gases, there to be reduced by solid carbon, with a consequent loss of heat to the hearth.

In modern practice this question is solved differently and more economically by permitting direct reduction to take place and at the same time offsetting the entailing heat loss by raising the blast temperature. The limit to which this direct reduction can be carried on depends on the ability to offset the resultant heat deficit in the hearth by higher blast temperature, and on the necessity to keep the top temperature above the desired minimum which is essential for the timely drying and preheating of the ore charges preparatory to their reduction by the furnace gases.

The results obtained may briefly be summed up as follows: Without raising the volume of wind blown, the amount of carbon gasified in the hearth and the weight of metallic oxides reduced per unit of time is increased. The furnace operates at a higher rate of output without requiring additional coke for its hearth reactions. As the cooling and radiation losses per ton of iron are inversely proportional to the rate of production, a saving is effected in this respect, which must ultimately find its expression in a lower coke consumption. As a part of the coke carbon is gasified by oxygen from the ore without the addition of nitrogen from the blast, the amount of gas per unit of burden material charged becomes less. The initial temperature of the gas leaving the hearth not being changed, this results in a lower top temperature as well as a lower temperature of the stack. The beneficial effect of this drop in stack temperature on coke consumption and on furnace practice in general will be dealt with later.

PREMATURE COMBUSTION

At temperatures below 900 to 1,000 deg. C. premature combustion does not take place to any appreciable extent, as can readily be seen from the curves of equilibrium established by Bondouard. Since its reacting speed grows rapidly with rising temperatures, it is evident that premature combustion must take place in the furnace stack at an increasing rate the higher the temperature of the zone in which the carbon dioxide and the coke come into mutual contact and the longer they remain in contact with each other at temperatures above 900 deg. C.; that is, generally speaking, the higher the average stack temperature of the furnace happens to be. Thus it occurs to a large extent in furnaces making high silicon iron, or furnaces operating on a highly refractory burden, for instance, of magnetite ores. Under such conditions, carbon monoxide is produced over and above the already existing abundance, which has resulted from extensive direct reduction, and which cannot be used to any advantage in the furnace.

In furnaces producing low silicon iron and operating on an easily reduced ore burden, premature combustion may also assume serious proportions, where the rate of driving is too slow and the time is thus unduly prolonged during which carbon dioxide remains within the regions of high temperature in contact with coke. The apparently logical means of counteracting this condition is "faster driving." In many cases this can only be practised after a change in the quality of coke has been brought about.

Among the ways and means which counteract premature combustion and are practised, aside from faster driving, I wish to mention one which is now so universally used that its value is often overlooked. I refer to the use of raw limestone as flux. Realizing that it took a considerable amount of heat to calcine the stone, and in an effort to relieve the blast furnace of this duty, the attempt was repeatedly made in past days to charge burned lime in the place of raw stone, but without attaining the expected improvement.

The explanation lies obviously in the fact that the endothermic calcination of the limestone, which takes place above 900 deg. C., is one of the most effective means to quickly bring about a cooling of the furnace gases below the zone of temperature where premature combustion can take place; it appears that thereby, and by simultaneously preventing premature fusion of the ores, which would place the latter beyond the reach of indirect reduction, more coke is preserved and made available for the generation of heat at the tuyeres than is necessary to furnish the heat required for the calcination of the stone.

Another most effective means of preventing premature combustion is the application of high blast temperatures. By thus accelerating combustion at the tuyeres, providing for the heat requirements of the hearth with less fuel and a consequently lower volume of gases, concentrating the zone of highest temperature and increasing the ratio of descending materials to rising gases, a decided lowering of the average stack temperature with correspondingly better fuel economy can be and has been accomplished. For instance, the blast furnaces at South Works, Illinois Steel Company, being operated according to these principles, have for

*From a paper presented at the Twelfth General Meeting of the American Iron and Steel Institute of New York, May 25, 1917.

[1]Superintendent of blast furnaces, Illinois Steel Company, South Chicago, Ill.

a number of years, in spite of a severe handicap in the form of irregular coke supply, not for a single month exceeded a coke consumption of 1,900 pounds per ton of iron for 21 consecutive months. During the year 1916, these same furnaces, with an average age of 331,771 tons per lining, produced 2,066,246 tons of iron on an average coke consumption of 1,854 pounds per ton.

From the analysis of the various reactions, it is evident that direct reduction and premature combustion in reference to origin, performance and prevention are two distinctly and entirely different processes, each one independently playing its own important part, in widely varying degrees, in every furnace operation. The only common tie between them is their endothermic character and the fact that they both consume carbon. The sum total of their carbon consumption represents what is usually called the amount of carbon gasified above the tuyeres. As this carbon is consumed partly by economical and partly by wasteful reactions in ever varying proportions, it is evident that the relation of this total "carbon gasified above the tuyeres" to the fuel consumption of a furnace cannot possibly have a direct bearing on the economy of the furnace operation.

CARBON DEPOSITION

To complete this review of blast-furnace reactions, I wish to mention one which in modern furnaces appears only occasionally to any extended degree. This is the decomposition of carbon monoxide according to the equation $2CO = C + CO_2$.

As the speed of this reaction is comparatively low, on account of the existing ratio of quantities involved, and since the zone of temperatures within which it can take place is limited to approximately from 400 to 600 deg. C., the extent of this reaction is, as a rule, slight. Theoretically it must be classed as economical, being exactly the reverse from "premature combustion." However, in practice, when this reaction takes place to any considerable degree, serious difficulties are encountered which make it extremely undesirable. The resulting carbon is deposited on the ores in a very finely divided form and interferes with their permeability to the gases, clogging the voids and causing a swelling of the charges, scaffold formation and all the serious troubles which follow.

When fine Mesaba ores were first used in larger percentages, such difficulties due to excessive carbon deposition were experienced more frequently. With furnace lines poorly suited for the smelting of these fine ores, particularly with the flat bosh angles then in use, irregular working of the furnace with protracted periods of hanging were nothing exceptional. The movement of the furnace charges being brought to a standstill for considerable periods of time, a much larger percentage of the materials in the upper part of the furnace stack was heated to a temperature where decomposition of carbon monoxide could take place, with a corresponding increase in the extent of this reaction as the result. Since then, however, furnace lines have been improved to such an extent as to make operating difficulties from this source a rare exception in Mesaba practice.

It has been observed, too, that a high percentage of hydrogen is often present when carbon is deposited in this manner. The reducing power of hydrogen relative to that of carbon monoxide increases with falling temperatures, and it is reasoned that, with a high percentage of the former, metallic iron in finely divided form is reduced from the ores at exceptionally low temperatures; this metallic iron then acts as a catalytic agent which greatly increases the reacting speed of the decomposition of carbon monoxide.

Excessive hydrogen in the top gases to an extent necessary to bring about such a condition is generally the result of defective apparatus, such as leaky hot-blast valves, tuyeres and bosh plates. If this be the case, the undesirable deposition of carbon can be overcome by removing the source of the hydrogen.

From the standpoint of an operating man, I have attempted to give a brief outline of a subject about which volumes have been written by men of science without ever covering the field. To them belongs the task of further theoretical exploration. We blast-furnace operators must be ready to apply and prove in practice.

Aluminium

ALUMINIUM is a material in which practically every owner of a motor car is interested. As most of us know, or knew once, aluminium is of extraordinary prevalence in nature, and is more abundant than any other metal, as it is said to constitute about 8 per cent of the earth's crust. So far as present indications go, it would appear that the motor car will become more and more like nature, inasmuch as it will consist to a larger extent than it does today of aluminium suitably alloyed with other metals. Interesting as aluminium may be to the motorist today, it appears that it will be still more interesting to him a few years hence. It certainly will be if the aluminium air-cooled engine should become prevalent.

When aluminium was discovered by Michael Faraday in 1827 he had no idea what he was building up. As Mr. E. Carey Hill pointed out in his paper on "Aluminium in the Motor Industry" read before the Coventry Engineering Society recently, twenty-seven years elapsed before aluminium was obtained in a perfectly pure condition. There is no doubt that the early aluminium was very tricky and unsatisfactory from a manufacturing point of view. It was stoutly maintained by many of the old school of engineers that aluminium was dirt electrolytically persuaded to become a metal, but ever ready to revert to its original state, and therefore they placed no faith whatever in it.

However, as Mr. Hill pointed out in his paper, from 1906 onward a vast amount of scientific research has been conducted in connection with aluminium, and some of the results are given in the periodical reports of the Alloys Research Committee of the Institution of Mechanical Engineers. Mr. Hill suggested that still greater advances had been made since the outbreak of war, as aluminium plays so important a part in the construction of the aeroplane that it has been a constant subject of research at the National Physical Laboratory and elsewhere. The full results of these later researches and experiments can only be dealt with after the war.

As everyone knows, the outstanding property of aluminium is its lightness; in its pure state it is only slightly above one-third the weight of iron, volume for volume. It is too soft to be used in engineering design unalloyed, but when alloyed this softness is corrected and its density considerably increased. It does not corrode at all readily in its pure state, and even when alloyed a dry atmosphere has practically no effect upon it. One of the most difficult aspects of its handling in the foundry is that its contraction during cooling is rather high, amounting to about three-sixteenths of an inch to the foot, and this property creates a number of difficulties which the art of the founder has to overcome.

It is probably not generally known that aluminium has been adopted in the electrical world to replace copper in large insulated cables for power transmission, as although its electrical conductivity is only 58.5 as compared with copper 97.5, yet, as its weight is less than one-third that of copper, volume for volume, this is no detriment, and, speaking roughly, an aluminium cable of equal conductivity to a copper cable would be 50 per cent lighter so far as its metallic portion was concerned.

Foundry experience has taught aluminium casters that there are certain main principles that must be adhered to, even with alloys, if good results are to be obtained systematically, and the factors which govern these principles are (1) the high contraction of aluminium during cooling, (2) the peculiar stage of plasticity through which it passes between liquid and solid, similar to common solder; and (3) its very low density at high temperatures.

In all casting it is difficult, where there is any sudden variation of thickness, to ensure that uneven cooling will not set up stresses or absolute defects, and owing to the plasticity of the aluminium during cooling it is very apt to be pulled apart at the junction of a thicker portion of the casting with a thinner part, and this is overcome by the scientific placing of "chills" in the mold on the face of a thick portion. In other words, heat reduction is accelerated in the thick portion, so that it and the thin portion may cool approximately at the same rate—another proof, if proof be required, that there is no little similarity between the processes of geology and those of the foundry.

The alloying of metals is one of the most complicated chemical processes, because all sorts of things which are unexpected to the layman are encountered. For instance, pure aluminium melts at a temperature of about 660° C., yet practically all the alloys commonly used rich in aluminium melt at a still lower temperature, though the addition of, say, copper, is the addition of a metal which has a higher melting point than aluminium, and therefore at first sight it would be imagined that the melting point of the alloy would be higher than that of the pure aluminium.

The alloys of aluminium with copper are of particular interest because both in alloys rich in copper and alloys rich in aluminium are found alloys which have properties of great value to the engineer: those with a low percentage of aluminium are nearly uncorrodible by sea water either alone or when attached to steel, and are only slightly corrodible in fresh water. Then at the other end of the series there is the alloy with only 1 per cent to 15 per cent copper and the rest aluminium, which is most valuable for many purposes. The alloys of aluminium, zinc, and copper have very considerable possibilities, and are used to a very large extent, but not so much research work has been conducted in regard to them as in the binary alloys, that is, the various proportions of copper and aluminium.

A number of other alloys were mentioned by Mr. Hill in his paper, but perhaps the most interesting referred to are manganese and magnesium. One and one-half per cent to 2 per cent of manganese with a small percentage of copper up to 4 per cent or 5 per cent, and the rest aluminium, give an alloy with great hardness, and the lecturer mentioned that 0.2 per cent to 0.4 per cent of manganese had been found in the alloys of which the angle and channel sections used in Zeppelin airship construction have been made. He also stated that the well-known Vickers alloy "Duralumin" contained traces of manganese.

Perhaps, however, the greatest indication of future developments came in the reference to magnesium, which has been much advocated as the means of producing a strong light alloy of aluminium. Its very low specific gravity—1.75 to aluminium 2.56—obviously means that the greater the quantity of magnesium added to the aluminium the lighter the resultant alloy becomes. On the other hand, with the majority of aluminium alloys the additional metal increases the weight. Unfortunately at the present time magnesium is rather difficult to obtain, as well as being expensive, but it has great possibilities which may and probably will be exploited at some later time.

Mr. Hill dealt at some length with aluminium pistons, but in the main he considered facts already well known to our readers, though in regard to the aluminium alloy piston he brought up the interesting fact that the tensile strength of copper alloys falls rapidly as the temperature rises, and it is therefore clear that the heat conductivity of aluminium is a very real help to the piston itself in a way not usually borne in mind. It was pointed out, however, that the ideal is to find an alloy which, while maintaining all the other advantages of an aluminium alloy, would also have the property that its tensile strength up to a certain degree would rise with the rise in temperature; such an alloy has indeed been discovered, but experiments are only in progress, and nothing more could be said about this. It will be realized that it is of the very greatest importance, because it follows necessarily that if an alloy in which rise in temperature increases strength can be successfully used, it is obvious that with the same margin of safety a still lighter piston can be used.

With regard to the working of aluminium pistons, Mr. Hill pointed out that they have been used most successfully with steel and cast iron cylinders, but on the whole better results were obtained in working aluminium against cast iron, as then, under suitable conditions, it was found that the walls assumed after long running just the same beautiful glaze as they do with cast iron pistons, and the wear was no greater than with cast iron.

Another interesting branch of the paper was in regard to die casting. Motorists hear a good deal about it nowadays, and they, in common with a good many engineers, are very hazy in their minds as to what it means, and we cannot do better than give the author's classification of the three distinct classes of the process, which are: (1) Casting under pressure into a mold which is entirely of metal (instead of the usual sand in which, of course, pressure could not be introduced); (2) casting without pressure into an entirely metal mold; (3) casting into a metal mold some small part of which such as a core, is of sand, because the nature of the casting is such that it could not be arranged in any other way.

The advantages of die casting are rapid production, accurate and uniform dimensions in the castings, thus reducing machining; a closer grain; increased strength in the metal in some cases; and last but not least an improved finish in the casting. So far as the motor car is concerned, die castings have been mainly employed for details such as magneto parts, electrical installation fittings and so on, but they can be used for crank cases, gear boxes, and other large parts.—*The Autocar.*

A Material for Ships' Propellers

AN alloy that has proven very satisfactory for ships' propellers, is turbadium bronze. This material has a tensile strength of 35-42 tons with an elongation of 14-20 per cent on a two-inch test piece, and it is not appreciably corroded by sea water. According to the *Chemical News* its composition is, approximately, copper 48 per cent; zinc 46, 45; tin 0.5; lead, 0.1; iron 1; aluminum 0.2; manganese 1.75; nickel 2.

The Cathode Ray Tube and Its Applications*

Methods of Construction, and Use as an Oscillograph and as a Wattmeter

By M. E. Tressler, Research Laboratory, Pittsfield Works, General Electric Company

THE cathode ray tube in its simplest form is a glass tube from which the air is exhausted to a vacuum of four to eight microns, *i.e.*, to an air pressure of 0.004 to 0.008 millimeters of mercury.

In one end of the glass tube is a small, flat metal disk which is connected through the glass to a terminal on the outside. This is the cathode. At one side, or in the tube about 15 to 20 cm. away from the cathode, is another metal electrode which is connected through the glass to a terminal on the outside. This is the anode. This is all that is actually required to produce the cathode rays, but in order to make use of them, the rest of the tube must be formed to a particular shape and several parts added.

The diaphragm is usually a glass or metal disk just below the anode which closes the tube with the exception of a small hole in the center of this disk about 0.4 to 0.8 millimeters in diameter. About 35 cm. below the diaphragm is fastened the screen on which the cathode particles strike. This screen is a metal, mica or glass disk coated with some salt which fluoresces when acted upon by the cathode rays. This fluorescence may then be observed visually or it may be photographed.

A sketch of the tube is given in Fig. 1. *C* is the cathode, *A* anode, *D* diaphragm, *S* screen, *R* palladium tube regulator, *F* focusing coil, *Q* quandrants.

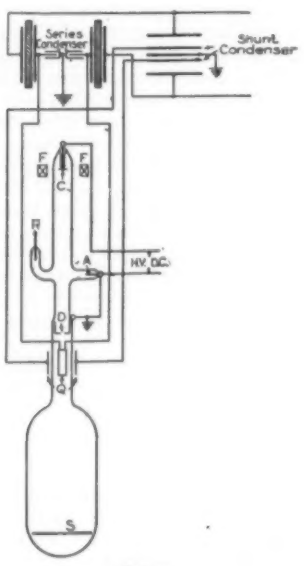


Fig. 1

The tube is operated as follows: The negative terminal of a high voltage (12,000 to 30,000 volts) direct current generator is connected to the cathode and the positive terminal to the anode, the anode being grounded. The voltage to apply depends upon the vacuum maintained in the tube, the steadiness of operation desired, the position, shape and connection of the focusing coil, the intensity of the magnetic field of the focusing coil and other minor influences. With this voltage applied there is a stream of electrons or negatively charged particles shot from the cathode normal to its surface with a velocity of 5,000 to 60,000 miles (8 to 96×10^9 cm.) per second, depending upon the vacuum in the tube and the voltage applied. This discharge of electrons is produced by the electric field between the cathode and anode.

The attenuated gas in the tube is generally understood to consist of a mixture of neutral gas molecules, *i.e.*, molecules where the positive and negative charges are exactly balanced; of gas molecules positively charged because they have lost one or more electrons or negative charges; and of free electrons which have been separated from the gas molecules, these being, of course, negatively charged.

As soon as the electric field is set up the positively charged molecules are attracted toward the cathode and the electrons are repelled. By the time the positively charged molecules have gotten to the cathode, they have attained sufficient velocity so that the force of the collision bumps off one or more electrons. The positively charged molecules in going to the cathode surface also run against neutral molecules and electrons with sufficient force to separate electrons from the neutral molecules and even to lose electrons themselves. The electrons, being negatively charged and of very much smaller size and mass than the molecules, are repelled with much higher velocity from the cathode than the molecules are attracted. These negative particles from the cathode pass down the tube to the diaphragm

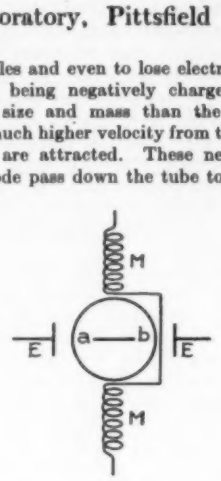


Fig. 2

Fig. 2a

where most of them are stopped, except a small beam which passes through the central opening and strikes the fluorescent screen. The diaphragm is grounded so that the charge that would tend to collect on it from the cathode particles is neutralized.

If the cathode surface was a perfect plane, all of the cathode particles would start normal to this plane, but as compared with the size of the cathode particles the unevenness of this surface is very large, hence some of the particles start off at an angle other than 90 deg. to the plane of the cathode surface. This tends to make the cathode discharge a diverging one, but even if this were not the case there would be a spreading out of the discharge, due to the repellant force between negatively electrified particles. This spreading out of the discharge is partially overcome by the focusing coil which gives a longitudinal magnetic field in the direction of the stream of cathode rays and which tends to concentrate the rays and hence increase the intensity of the beam passing through the opening in the diaphragm.

The palladium tube regulator which is connected opposite the anode is used for regulating the vacuum when there is an increase of vacuum due to a long continued use of the tube at high voltage. The palladium tube is sealed in the glass and closed at its outer end. When heated to a red heat it allows a small amount of gas to pass through, and hence raises the gas pressure inside the tube.

The diaphragm must be made of a sufficiently dense, thick material so that the cathode rays will not pass through it. A platinum diaphragm 0.005 in. (0.127 mm.) thick will allow the cathode particles to pass through it. A brass cup with walls 0.030 in. thick is commonly used and found satisfactory.

The screen in order to be fluorescent is coated with

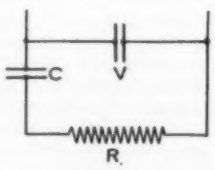


Fig. 3

willemite, zinc sulphide or calcium tungstate. The willemite gives a yellowish-green, fluorescent light when excited by the cathode rays, which is very bright to the eye but is not very active actinically, *i.e.*, when photographed it does not act rapidly on the photographic plate. The zinc sulphide is said to be very actinic, and is used by a great many experimenters with the cathode ray tube. Calcium tungstate has been found to be the most actinic and best suited for our work thus far. It gives a bluish-white fluorescence which is quite brilliant, both visually and actinically.

OTHER METHODS OF PRODUCING CATHODE RAYS

There are several other forms of cathode ray tubes where the electron or cathode discharge is produced in a different manner. Wehnelt's method of obtaining an electron discharge is to coat a platinum strip with a thin film of lime and then to heat the lime to incandescence by causing an electric current to flow through the platinum strip. He has shown that the incandescent lime emits copious steams of electrons in comparatively weak electric fields. This discharge is also largely due to the bombardment of the hot lime by the positive ions or gas molecules, but it is also due to the high temperature zone into which these positive ions flow, the electrons being much more readily separated from them. Of course the velocity of the electrons emitted from the hot lime is very much lower than those which are repelled under a very strong electric field.

The latest and probably the best method of obtaining an electron discharge in a cathode ray tube is by means of the hot tungsten cathode in a very highly exhausted glass tube where the glass and all of the metal parts have been kept in this high vacuum at a high temperature for a sufficient time to get all of the gases out of them.

When the cathode (which in this case is a tungsten wire filament heated to high temperature by an electric current flowing through it) is connected to a high voltage, there is a pure electron discharge from the cathode with no accompanying positive ion bombardment; the tube having been exhausted to such a high vacuum that there is an inappreciable number of positively charged molecules or ions present. In this case the electrons must

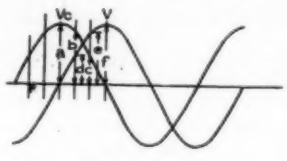


Fig. 4

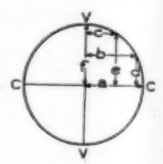


Fig. 5

come from the metal filament itself; the number of electrons, or, in other words, the current flowing depending upon the temperature of the cathode and the voltage applied, and the velocity of the electrons depending upon the voltage only.

USES

The cathode ray tube in practice has been used as an oscillograph and as a wattmeter for measuring very small amounts of power at low power-factors and high voltages. In order to use it as either one of these instruments it requires some method of deflecting the beam of cathode rays after it has passed through the opening in the diaphragm and before it has reached the screen. This is accomplished by means of a transverse electric or magnetic field applied a short distance below the diaphragm opening.

The cathode particles carry a certain charge or quantity of negative electricity and hence when an electric field is applied at right angles to the direction of travel of the particles they are deflected parallel to the direction of the field and if a magnetic field is applied they are deflected at right angles to the direction of the field. This is shown in Fig. 2 where the circle is a section of the tube just below the diaphragm and *M* is a set of magnetic quadrants and at *E* a set of electric quadrants. The deflection due to either field is in the line *a-b*.

As accurately as can be measured from photographs, it is found that the deflection of the fluorescent spot on the screen due to the field is directly proportional to the strength of the field; that is, to the voltage applied or to the current through the coil. This is so because the angle through which the beam is deflected is quite small, and therefore the arc of the circle, whose radius is the distance from the quadrants to the screen, through which the spot would travel, is not appreciably different from the distance on the surface of the screen, which is the tangent of the angle. If an alternating voltage is applied, the fluorescent spot vibrates back and forth once per cycle, which makes it appear as a line across the screen.

In order to use it as an oscillograph, it is necessary to have a photographic plate move at right angles to the

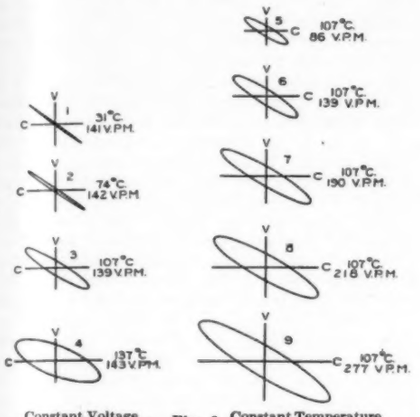
*From the *General Electrical Review*.

direction of vibration of the spot which thereby will show the wave shape.

When it is required to use the tube as a wattmeter, two pairs of quadrants at right angles to each other are required; on one pair a voltage proportional to the current flowing in the circuit is impressed and on the other pair a voltage proportional to the total voltage drop across the apparatus under test is applied.

It is be noticed here that we have assumed that an electric field is used for each pair of quadrants, this being more convenient where losses at high voltages and very small currents are being measured.

The voltage for the current quadrants may be obtained from the potential drop over a capacity or resistance in series with the apparatus or material under test. If a capacity is used the area of the figure traced on the screen will be a maximum when the power-factor is 100 per cent, whereas, when a series resistance is used the



Constant Voltage, Variable Temperature **Fig. 6** Constant Temperature, Variable Voltage

area will be a maximum when the power-factor s 0i per cent. The voltage for the voltage quadrants may be obtained through a potential transformer or from a capacity shunted across the line using two plates of this condenser to step down the voltage. The operation as a wattmeter is shown in Figs. 3, 4 and 5.

Assume that it is desired to determine the loss in a high resistance when subjected to high voltage. The voltage drop over a condenser in series with the resistance is used to produce the current deflection when connected to the current quadrants and the voltage drop over a part of a condenser shunted across the resistance and series condenser is used to produce the voltage deflection when connected to the voltage quadrants, as shown in the circuit of Fig. 1. Taking the simple circuit in Fig. 3, the current in C is in phase with the current in R, but as C is a pure capacity the voltage must be lagging 90 deg. behind the current. This wave is plotted as V_c in Fig. 4.

The voltage across the condenser V is in phase with that across the resistance R and capacity C in series; the wave is plotted as V in Fig. 4, 90 deg. out of phase with the voltage across the series condenser. This is not exactly correct as the voltage across condenser V is at a slight angle to the voltage across the resistance R, depending upon the voltage drop over the condenser C. However, this is not large, as the voltage over the con-

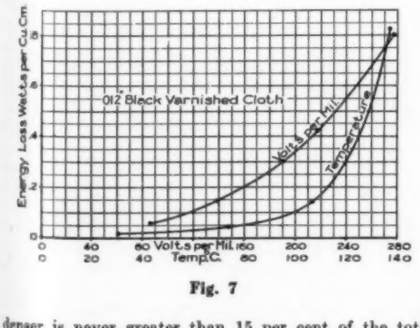


Fig. 7

denser is never greater than 15 per cent of the total voltage across the condenser and loss together.

This slight phase angle is corrected for in determining the true power-factor, by calculating the angular difference due to this series condenser and subtracting it from the measured θ', where $\cos \theta'$ is the measured power-factor, leaving the angle θ whose cosine would be the true power-factor of the material under test.

Now, if we take the line in which the fluorescent spot vibrates, due to the voltage across the series condenser as the axis of abscissa, and the line due to the voltage across the shunt condenser as the axis of ordinates, and plot instantaneous values of the two waves in this coordinate system, it will be seen that the fluorescent spot traces out a closed figure, Fig. 5, on the screen which will be a circle, ellipse or straight line, depending upon, the relative amplitudes of the two voltages and the power-factor of the loss being measured.

In order to know what this loss is in watts, the voltage drop across the series condenser is measured with an electrostatic voltmeter and from the known capacity of this condenser and the frequency and wave shape of the voltage the current flowing in the circuit can be calculated. The current and voltage are now known and it becomes necessary to obtain the power-factor, when the watts can be calculated.

The power-factor is found to be the ratio of the area of the figure as measured, to that of the maximum area which could be obtained with the separate measured deflections. This is determined briefly as follows: The area of the maximum ellipse is $\pi\ ab$, where a is the semi-major deflection and b is the semi-minor deflection. The area of the ellipse, which measures a loss whose power-factor is $\cos \theta'$, would be $\pi\ ab \cos \theta'$.

Hence $\dfrac{\pi\ ab \cos \theta'}{\pi\ ab} = \cos \theta'$, or power-factor, which is the measured area divided by the maximum area calculated from the separate deflections.

With a sine wave in both coördinates, the maximum area would be $\pi/4$ times the product of the length of the two coördinates VV and CC. Then the measured area of the figure divided by the maximum area gives the power-factor. Hence we have measured the voltage, current and power-factor and then can readily calculate the loss.

In Fig. 6 is shown two series of losses; one is the dielectric loss *vs.* temperature on black varnished cloth at a given constant voltage, and the other is dielectric loss *vs.* voltage at a given temperature.

The law of variation of dielectric loss in insulations with variation of temperature and voltage has not yet been determined. If the loss were similar to a resistance loss, we would expect that it would vary as the square of the voltage if the temperature could be kept constant. However, there are several factors which enter into the problem, such as the thickness, area, thermal conductivity, specific heat of and the amount of moisture in, the material under test, the size and material of the electrodes, length of time the voltage is applied, etc., that make the calculation quite difficult and unsolved as yet.

The Fermentation of Indigo

At the suggestion of the Indigo Chemist an enquiry was undertaken into the bacteriological aspects of the fermentation taking place in the indigo steeping vat. As might have been expected, many important facts in connection with the great variations in yield which are known to occur for no obvious reason were brought to light by this enquiry, which, however, has not yet proceeded far enough to afford any complete explanation of the results obtained. It is clear, however, that the success of manufacture as at present carried out depends primarily upon the presence and action of specific bacteria in the steeping vat, and further that in some cases an adverse result is due to the activity and deleterious influence of others. It is a well-known fact that during the earlier days of manufacture the yield of indigo is low but becomes rather suddenly higher, remaining so as long as continued use of the vats persists. Any vats not utilized at first but brought into operation later, exhibit the same phenomenon, clearly showing that the latter is not due to changes in the plant, the water, or methods of manufacture. Well attested cases have been observed of differences in yield of as much as one hundred per cent or more between head factories and their outworks manufacturing plant grown under similar conditions of soil and climate, and it was possible in one instance to arrange to exchange indigo plant from one such factory to another thus eliminating any possible influence of this factor, but without altering the previously observed differences in the respective yields. The most obvious conclusion seems to be that such differences are due to the presence or absence of specific bacteria which multiply in and infect the steeping vats, increasing in number and consequently in their influence upon the character of the fermentation up to the limits of the permanent substratum (in this case the walls and floor of the vat) upon which they remain from one operation until the next; this supposition is supported by observation of the easily verified fact that fermentation commences in the immediate neighborhood of the walls of the vat and gradually spreads therefrom towards the center. Here we have an analogy which such functions as that of the "starter" in dairy work and the bacterial slime of the sewage filter bed, and very probably under natural conditions with the micro-organisms responsible for the retting of jute and flax. Many industries depend upon the intervention of micro-organisms, but whereas in some of them the presence of desirable species and the absence of deleterious ones is ensured by artificial measures as in the case of brewing and distilling, in others it is assumed that the proper organisms will be naturally present in sufficient predominance to ensure satisfactory results. This is the case with such native Indian industries as the fermentation of "Toddy" and "mahua" the retting of jute and the steeping of indigo, but it is becoming daily more clear that the distribution of the necessary and proper micro-organisms is by no means so universal or so fortunate as to carry these and similar operations outside the range of practical artificial regulation.

The inquiry in connection with indigo is at present in too early a stage to warrant any confident assumption that it will be possible to apply the methods of the distillery or the dairy with economic success to a raw material, such as the indigo plant, but should further work confirm the conclusions set forth above, it would appear that very considerable improvements in the methods of manufacture may be obtained by artificially ensuring the presence of the necessary organisms in the steeping vat.

It has been ascertained that two distinct types of fermentation may be found in the steeping vats, one in which copious evolution of nitrogen takes place the only other gas given off being carbon dioxide, and the other in which hydrogen is liberated in addition to these two. In the former case, during the factory period of fermentation, about twelve hours, nitrogen forms sometimes as much as 98 per cent of the evolved gases the remainder being carbon dioxide; later these proportions are slowly reversed, but this reversal is of no importance as not affecting factory conditions and requiring 48 hours to 60 hours to complete.

In the second case the evolved gases after 12 hours are composed of about equal parts, some 33 per cent each of nitrogen, hydrogen and carbon dioxide. It is remarkable that no trace of methane has been found in any of the numerous fermentations carried out, and it is also of great interest to note that in some instances in contradistinction to the high nitrogen evolution frequently found, very small quantities of this gas were evolved.

It is clear therefore that the character of the fermentation must be governed by that of the bacterial complex fortuitously present, and that this may vary essentially and profoundly even in contiguous localities. This variation will have a special interest and importance in connection with the decomposition of organic matter in soil under varying conditions, and must be taken into careful consideration in advancing any theories based upon observation of chemical changes due to bacterial action in soils under otherwise apparently similar conditions.

Numerous species of bacteria have been isolated in the course of this enquiry and their physiological activities with regard to the processes of fermentation investigated. It has been possible to place some of them definitely, either in the class of beneficial or deleterious organisms, but much further work will have to be done before their true functions in this connections are fully understood. It is of interest to note that one bacterium has been identified with the unfortunate condition which sometimes arises in the "beating" or oxidizing process known as "green vat."—Annual Report of the Board of Scientific Advice for India.

Observations on the Friedel-Crafts Reaction

A reversal of the Friedel-Crafts reaction can in general be brought about with more or less facility by the action of aluminium chloride on the alkyl-benzene in presence of a large excess of benzene. In the case of the xylenes alone, this reaction does not succeed, but when polyethyl-, isopropyl-, butyl-, and amylbenzenes were boiled with aluminium chloride in presence of ten times their weight of benzene, quantities of the monoalkylbenzene, varying in each case were formed according to the scheme:—

$$C_6H_4(C_2H_5)_2 + C_6H_6 = 2C_6H_5(C_2H_5).$$

Of the greatest interest however was the formation in excellent yield of toluene and cumene from cymene, which is available in large quantities as a by-product of the sulfite-cellulose process. Ninety grms. of cymene in 900 grms. of benzene gave, on boiling for 10 hours with 4.5 grms. of aluminium chloride, a yield of 44 grms. of toluene and 68 grms. of cumene, corresponding to 80 per cent of that theoretically possible, leaving a residue of only 3–4 grms. of gummy material. The polyhalogen derivatives of benzene could not be decomposed by the action of aluminium chloride and benzene in this manner.—Note in *Jour. of Soc. of Chem. Ind.*, in a paper by E. Boedtker and O. M. Halse, in *Bull. Soc. Chem.*

Radio-Active Luminous Paints

Substances That Are Being Found of Value During the War

By Arthur H. J. Keane

SINCE the commencement of the present Great War there has been a rapidly increasing demand for such luminous articles as radium watches, luminous compasses *et hoc genus omne*, more especially for use in the trenches and in the open fields, where other sources of artificial light are not available—and, if they were, their use would be accompanied by serious risks. Already since the beginning of the seventeenth century certain substances have been known, such as phosphorus for instance (which possesses the power of shining in the dark), provided they have first been exposed to daylight, gaslight or any other luminous source. The best known of these products is Balmain's Luminous Paint, consisting of a sulfurous combination of calcium made with the aid of a high degree of heat. As at the present time, it was also once used frequently for painting the curbstones at dangerous curves, and in dark positions, so as to render them visible at night. This practice was revived this winter in London where, in the darkened streets, they often proved of very great service. The luminosity of such substances may be explained as follows: Phosphorescence takes place if the sulfide of an alkaline earth (calcium, strontium or barium), or of zinc, be roasted with traces of certain metals and with a fusible addition, mostly in the form of a colorless salt. As foreign metal, copper, zinc or bismuth is more especially used, an extremely small proportion of which is added to every ounce of sulfide. Under the influence of light these substances throw off electrons, or negatively charged ultra atomic particles, while the molecules charged with positive electricity remain behind and form positive ions. As soon as the exposure to light ceases the electrons, owing to the electric forces, endeavor to reincorporate themselves with the ions. Due to the low electric conductivity of the sulfides this, however, only takes place with excessive slowless, and the radiation of light is thus produced by the reunion of the electrons with the ions.

Such phosphorescent substances, however, are not suitable for use in the field, as they always require a prior exposure to light which, in the case of a watch that is always carried in the pocket, can easily be forgotten. A further drawback lies in the fact that, after a few hours, the phosphorescent light becomes so dim or exhausted that it no longer exerts any useful effect upon the eye. This is especially the case with those phosphoruses which give a very strong light immediately after exposure, such as sidot blend (crystallized zinc sulfide).

In the year 1899 Bocquerel found that radio-active preparations diffuse a weak light. Furthermore, he found that radio-active substances were also able to impart light-giving properties to other bodies. Thus, for instance, a diamond, when placed close to them, gives off a white light; this is also a process for differentiating between genuine stones and imitations. The luminosity of these substances is caused by invisible rays which emanate from the radio-active substances. The term radio-active is one which is applied to bodies which, in contradistinction to the chemical elements hitherto known, do not exist permanently but in course of time change into other basic substances. Their decomposition is mostly, but not always, accompanied by the irradiation of rays of light. These rays consist mostly of positively charged helium atoms (so-called alpha particles), which are thrown off with a velocity of about ten thousand miles per second, and they compose about 90 per cent of the total radiation. Other substances, on the contrary, send out beta rays, negative or electrons. In spite of their great velocity, which is almost equal to that of light, yet their energy amounts to about 5 per cent of the total radiation. About the same is the action of the last rays, the gamma rays, which—in contradistinction to the two preceding groups—do not consist of single particles but are very short ether waves like the Roentgen rays.

Now the alpha rays are those which have an effect upon certain substances similar to that of light, *i.e.*, they split up the molecules into ions and electrons, the reunion of which is accompanied by the irradiation of light. In order to obtain a good effect it is advisable, especially in these cases, to add sidot blend to the radio-active substance because, as we have already seen, this blend has the strongest effect in producing the radiation of light. That this light soon dies away is, here, not taken into consideration as the sidot blend owing to the continued radiation of alpha rays is, so to speak, permanently re-excited by the admixture of the radio-active substance.

A radio-active luminous paint differs, therefore, from the formerly known phosphorescent substance[1] in the fact that it does not require any prior exposure to light. On the contrary the excitement or action is, in this case, produced permanently by the rays which are thrown off without interruption by the radio-active substance contained in the luminous paint.

As already remarked a radio-active substance is not permanent, but gradually changes into other, also radio-active, stuffs. Thus, for instance, radium changes into a gaseous body (the so-called radium-emanation) which in its turn, changes successively into further solid bodies of which so far six are known to science as Radium A, Radium B, etc., up to Radium F, such a group being termed a "Radio-Active Family." A second and third family are formed by thorium and actinium respectively with their products of decomposition. Due to this gradual conversion the primary, or fundamental, substance is of course not permanently maintained. The periods of time, within which such a substance disappears, differ very considerably. Hence the semi-value periods (*i.e.*, the time within which one-half of the substance has decomposed or "disappeared") are 1,690 years for radium, and about four days only for the radium-emanation. Mesothorium, which is also used for clinical purposes, is obtained from the manufacture of incandescent mantles and has a semi-value period of about five and one-half years; the radio-thorium obtained from mesothorium, and the thorium X obtained from the latter, have a semi-value period of two years and a little less than four days respectively. The same periods for the actinium series are so small, that for practical purposes, it is not necessary to take them into consideration at all.

Of the substances named radium alone possesses a sufficiently high semi-value period so that, apparently, radio-active luminous paints can only be secured by adding radium to the sidot blend. This assumption would be quite correct if the duration of a luminous paint depended merely upon the addition of the radio-active ingredient, and if the sidot blend remained unchanged. As a matter of fact, however, this is also changed in course of time by the continued "bombardment" of the alpha rays, so that the radiation of light steadily declines; this it does all the more rapidly the more powerful the excitation and the brighter the initial light. In very strong luminous paints a marked diminution in the power of the light is noted already after a lapse of six months. Hence it is of no use, at least in the case of a strong luminous paint, to add radium to the ingredients; in fact it is far preferable to use mesothorium which does not throw off any alpha particles itself and, thus, apparently seems to contradict the statements already made. Yet, in truth, pure mesothorium does not produce any light effect. Now technical mesothorium contains from 15 to 25 per cent radium; furthermore it also gradually becomes converted into radiothorium which gives off the alpha rays and is thus highly effective. Hence a freshly prepared mesothorium luminous paint will triple or even quadruple its lighting power during the first four and one-half years, after which it first gradually begins to decline. Hence it is advisable to add a certain quantity of radiothorium to the mesothorium, whereby the throwing off of rays will steadily increase during the first five years, and will not regain its initial value till after ten years; after this latter period it will gradually decrease in power. But if it be taken into consideration that the action of the sulfide of zinc causes a gradual decrease in the lighting effect, then the initial rise in the efficiency of the radio-active substance will tend to counteract the decrease in the radiation of light, owing to the exhaustion of the sulfide of zinc, so that such a mesothorium luminous paint will possess a constant brilliancy during the first three to five years. Also for a further five to ten years they would also give a fairly good light in most cases, so that the useful life of such a luminous paint may be estimated at a period of ten years on the average. In the case of a pure radium luminous paint the lighting power begins to decline *ab initio* due to the exhaustion of the sulfide of zinc, which acts as the light carrier, so that it would become useless within this period.

For very strong luminous paints, however, the addition of mesothorium is not economical. In these cases the exhaustion of the sulfide of zinc is so strong, that the light intensity already becomes practically useless within from one to two years. This could be improved by the addition of pure radiothorium.

[1]Not all phosphorescent substances respond to alpha ray.

As the radio-active luminous paints contain about 1–60 milligrams of radio-active substance to every 100 grams of sulfide of zinc, and as a milligram of radium costs from £20 to £25 and a milligram of mesothorium about £10 (radio-thorium is cheaper), hence a really good luminous paint must not be expected to be cheap. This, naturally, gives rise to the temptation to mix cheaper substances into the paints, the principal substitute being thorium X; as its action, however, diminishes by 50 per cent in 3.65 days, the admixture of this substance makes itself apparent within a very short space of time. To determine the exact amounts of radium, mesothorium and radiothorium contained in a luminous paint is a difficult matter for the expert, and quite impossible for the dealer and buyer. To render such an investigation possible quantities of about 15 grams would be necessary; furthermore, as the radio-active substances are added in the form of insoluble salts, it would be necessary to chemically flux the luminous paint. These are processes which can only be carried out with a very well equipped laboratory while, owing to the large quantities of the various substances required, they are very costly. The purchase of a radio-active luminous paint is, therefore, more or less a question of blind trust and should only be made from some highly reputable firm or factory whose *reputation* is in itself a guarantee for the goodness of the paint.

It is also extremely easy to make a mistake even when merely testing the substance externally. As sidot blends belong to the so-called phosphorescent substances, and become luminous after exposure to light, hence a radio-active luminous paint which has been exposed to day or lamplight appears much more luminous than when it has lain in the dark for some time. It must, therefore, first of all be placed for several hours in a dark room or in a closed receptacle before it is possible to test its actual lighting power. A simpler way is to expose the luminous paint for a few seconds to dark-red light—such a lamp as photographers use in a dark chamber for instance—as the red (and more especially the ultra-red) rays will cause the phosphorescence to disappear very rapidly.

Luminous paints are mostly used in a powdered form, and are applied to the articles it is desired to coat with the aid of an alkaline gum-lac (acid lacs would destroy the sulfide of zinc). This process, however, is not a practica lone, as the lac can easily entirely envelop the individual grains or particles, and thus hold back and prevent the alpha particles thrown off by the radio-active substance from exerting their influence.

A coating of lac is nevertheless necessary so as to retain the gaseous emanations which, otherwise, would escape into the surrounding air; it is precisely these emanations and their products of decomposition, as they also mostly throw off alpha rays, which substantially enhance the luminous effect.

Radio-active luminous compounds are being more and more widely used—especially since the outbreak of the present War of the Worlds. For watches relatively weak paints suffice, but for compasses a much stronger compound must be used because, in the twilight prevailing in the open, the eye is always adapted to the reception of a weak light effect. Especially strong compounds must be used when it is desired to distinguish not only individual points, but also figures or letters, at a considerable distance. These paints are also largely used just now in connection with military work but, for obvious reasons, it is not possible to deal with these at the present juncture. We may, however, mention that very great benefit has been obtained from these paints when used at night time in the streets, darkened to prevent attacks by the German Babykillers. Luminous buttons for pedestrians, walking sticks and umbrellas with luminous handles, luminous buckles and shields for mens' hats and policemen's helmets, have all done good service and prevented many a collision on the pavements and loss of life when crossing the roads. In dark private roads, letter boxes, trees, and so on, have also been given a few dabs of this shining mass, to the great gratitude and relief of those whose business or pleasure compelled to wander late at night through the Stygian darkness of the London streets in War Time.

EDITORIAL NOTE.—Commenting on the above article, Dr. Charles H. Viol, Director of the Radium Research Laboratory, Pittsburgh, has the follwoing to say: "As far as I know mesothorium has only been produced on a commercial scale in Germany, and while some amounts of this material are being used at present, even in this country, in the production of luminous compounds, I

am at a loss to understand where any considerable supplies of this material might be obtained.

"You can realize the difficulties of the mesothorium producer when you know that there is one part of radium for every three million parts of uranium in an ore, whereas because of the shorter life of mesothorium, there is only one part of mesothorium (measured in terms of the gamma ray radium standard) for something like sixteen million parts of thorium. Consequently the mesothorium producer has to produce a rarer product, and has to market his material at a lower price than radium; and this, with the present high cost of production, does not conduce to mesothorium production.

"Another point with regard to the use of radium in phosphorescent materials, which is the subject of error, is that the addition of radium to any phosphorescent material will produce a permanent luminous compound by reason of the action of the radium rays. This is not the case at all, since only those substances which are sensitive to the alpha rays, as is the case with zinc sulfide, can be used for this purpose. Willemite, which glows splendidly under the beta and gamma rays of radium, shows no alpha ray scintillation, and consequently only a very low degree of luminosity when mixed with radium. Calcium sulfide shows no luminosity due to alpha rays when mixed with radium. Alone, as a phosphorescent substance it is superior to zinc sulfide in its power of maintaining phosphorescence for a number of hours."

The Oil Fields of the Apsheron Peninsula*

Richest Lands in the World Contained Within Russia's Barren Promontory

AMERICANS, who now so often "strike oil" without having anything to do with petroleum, can hardly be expected to know that the most remarkable oil land in the world is not in Pennsylvania, or even in the United States at all, but is mainly included in the famous Apsheron Peninsula, which projects from the southern border of European Russia into the western side of the Caspian Sea.

The peninsula, with perhaps a part of the Caspian Sea area, is in fact the center of the most prolific and complicated oil-bearing axis in the world. It is a part of the tectonic (or earth-building) axis which extends to the west and northwest through the Caucasus range, the Balkan ranges, and the Carpathians. This axis is oil-bearing in Galicia and Rumania. In the Balkans there are no known oil deposits. But on the north slopes of the Caucasus very rich fields have been tapped, as at Grozny and Maikop; in the Apsheron Peninsula we reach the richest oil lands yet discovered. Apparently the oil-bearing sands of this axis extend even farther to the east and northeast, for there are the newly developed Emba fields just to the northeast of the Caspian, and other sources, as yet little exploited, in the trans-Caspian districts.

Though Russia has had to yield first place in total oil production to the United States, experts hold that the ultimate resources of the fields about the Caspian are likely to prove greater than those of any other regions yet known. Even before the recent exploration of the Emba and other fields in the Ural Province, it was estimated that the Russian oil fields covered an area of at least 14,000 square miles. How little this has been touched will appear from the fact that previous to 1903 the whole of Russian petroleum had been taken from an area of less than 20 square miles, while all but a small fraction of the total quantity had come from less than 10 square miles of land. Every year discloses new areas where signs of oil and gas promise large yields in the future.

FROM FIRE-WORSHIPPERS TO PIPE-LINES

The history of petroleum on the Apsheron Peninsula is a long and varied one. The natural gas exudations and oil deposits of this region have been known for many centuries back. The existing site of the Temple of Fire-Worshippers at Surakhany, near the point of the peninsula, has been visited by members of that cult for more than 2,500 years. Baku petroleum, according to historians, has for centuries past been collected by the Persians and sent into Persia and inner India, where the white variety that is found in several parts of the peninsula was used as a medicine both internally and externally.

Formerly the Apsheron Peninsula belonged to Persia. Peter the Great annexed Baku in 1723; it was restored to Persia in 1735, and again reoccupied by Russia in 1806. The Government granted a monopoly of the first infant petroleum industry here. Later, in 1872, the monopoly was abolished and an excise tax on the industry substituted. In 1877 this tax was removed, and then the industry began to expand rapidly. This was six years after the first oil well was bored on the Balakhany plateau. Previous to 1871 all Russian petroleum was obtained from hand-dug surface pits, of which the deepest was seldom more than fifty feet. With the boring of wells came gushers, and such a sudden increase in the supply of petroleum that for a time the industry was quite demoralized by the superabundance. It was the famous Swedish brothers Nobel, Ludwig and Robert, who actually revolutionized the Baku oil industry. They built and operated at Baku a modern refinery, run on the most scientific methods, and built the first pipe-line from the Balakhany field to the refineries at "Blacktown" (Chorny Gorod), which is the oil-industrial part of Baku, to the eastward of the residence and business district. Before this, the oil from Balakhany had been conveyed to the refineries in barrels on two-wheeled Tartar carts, a long string of these occuping the "road" all day long. Other firms, at first as skeptical about the pipe-line as the carters were enraged, were soon converted, and the oil carts were wholly abolished. Tank vessels plying on the Caspian to the mouth of the Volga soon followed, and the modern industry was established.

NATURE OF THE APSHERON COUNTRY

The peninsula itself offers a striking topography and appearance. As its base, or western part, nearest the Caucasus, it reaches an elevation of about 900 feet, declining towards the Caspian until along the shore its greatest height is about 100 feet. It is bare and waterless except for salt lakes,—altogether austere and forbidding in appearance.

No study for the geology of the region has been made by the Russian Government, and what is definitely known of it is contained in the records of engineers and of companies which have done much exploitation work. Both in the peninsula and farther west, the oil-bearing strata antedate the formation of the ridges of the Caucasus, which are of comparatively recent formation.

THE DEVELOPED OIL AREAS

The chief oil areas so far developed on the peninsula are the three older fields,—Balakhany, Saboontchy, and Romany, which embrace an area of about four square miles on a plateau at an elevation of about 175 feet above the Caspian; the Bibi-Eibat, three miles south of Baku; and the new fields of Binagady and Surakhany. The first drilled oil well in Russia was put down in the Balakhany field, where previously, as elsewhere in Russia, oil had been obtained only from hand-dug wells or pits. Drilled wells followed in the other two of the older fields, and in a short time this small area had proved itself the richest patch of oil land in the world.

Bibi-Eibat is a peculiar region,—a low-lying, curved bay of flat land on the Caspian shore, hemmed in by bluffs. Here the oil-bearing series of strata, which are estimated at 2,000 feet in thickness, dip under the Caspian Sea. In order to get at the oil in this very rich field, the Russian Government some years ago began to fill in along the sea edge, so as to make the deeper-seated oil accessible to boring. The results have amply justified this measure in a very large oil production. The oil at Bibi-Eibat differs from the other oils by its richness in paraffin.

OIL GEOLOGICAL CONDITIONS

The first geological condition necessary to the storage of petroleum is a porous stratum in which the oil can accumulate; the second essential is the presence of an impervious stratum overlying the bil bed to prevent the displacement of the oil by water, and to stop the escape of petroleum gas. The pressure of the confined gas on the stored oil is of great practical importance, since it is the gas pressure which produces "gushers," or fountains, from which the most rapid output of oil is obtained. The first condition is inevitable if the formation of the petroleum is the result of the decomposition of organic matter contained in the stratum, for the oil simply takes the place of the original substance. But the commercial value of an oil district depends upon the degree of porosity of the oil-bearing strata, as the degree of porousness determines how large an oil area can be drained by a single bore-hole in a definite time—in other words, the porousness determines the rate of production. The second condition, that of the overlying, impervious stratum, is probably responsible for the existence of the petroleum, since without this covering oil would probably never have been formed, or, if formed it would have escaped. It is the amazing porosity of some of the Baku oil sands, says A. B. Thompson, a British expert on the Baku district, that has led to such phenomenal producers in these fields; 200, 300, and 400 cubic feet of petroleum, mixed with nearly an equivalent weight of sand, and hundreds of cubic feet of gas being ejected per minute from a bore-hole.

The oil of the Apsheron Peninsula is secreted in lens-shaped pockets of sand which do not communicate freely, if at all, with each other, although occasionally, after the removal of much sand and oil, as may be caused by the perforation of strata by a bore-hole, the barriers which have separated distinct oil beds may be broken down, and communication between them established. There is no relation between the sea-level and the levels of oil in wells, for both on the Balakhany plateau, and at Bibi-Eibat at sea-level, the petroleum at times spouts up two or three hundred feet above the Caspian level; while at other times the oil level is as much as a thousand feet below the Caspian surface.

The pressures met with in the Russian fields are asserted to be almost beyond question due to the presence of gas held in solution in a very compressed state by the petroleum, until release of pressure is given by a bore-hole penetrating to the gas-charged oil.

Mr. A. B. Thompson has written so much the best account of the Baku and Apsheron oil fields, both in their scientific and picturesque aspects, that no apology is needed for giving here some brief quotations from his book "The Oil Fields of Russia."

WHEN OIL "FOUNTAINS" SPOUT

"Excitement" is a term used by Thompson for the striking phenomena which attend the flowing of an oil "fountain," or "gusher," as an American would call it. He says of this:

When, in the Baku district, a fountain is flowing, the disturbance created in the oil stratum must be terrific, for the surface of the ground quivers for a radius of a quarter of a mile, and the noise produced by the violently expelled oil, gas, and sand can be heard for miles. It may be impossible accurately to describe the subterranean movement at such moments, but a little consideration will inevitably lead one to construct a mental picture of the kind of active changes taking place a thousand or more feet below the surface.

It is not improbable that the larger fountains in the Baku oil fields are partly due to the excitement or reaction occasioned by a flow of oil. At first, oil steadily overflows the casing, through supersaturation with gas; but immediately the heavy column of liquid is partly expelled, and a large part of the resistance removed, a violent rush of gas, carrying with it oil and sand, occurs toward the shoe of the tubes, with the result that exit is suddenly closed, and a violent check is momentarily imparted to the moving mass in the earth. For an instant the slow movement of a solid plug in the tubes prevents further admission to the tube; but as the upper pressure is still more relieved, and the pressure of gas below rises, the temporary resistance of the sand-plug is overcome, and the mass is ejected with terrific impetuosity up the tube. The sudden release of pressure thus afforded causes another inrush of sand, and the action just described is repeated. There is, in fact, a constant water-hammer action going on in the sand stratum, which probably plays no small part in opening up oil ground for a considerable area around the bore-hole—an area that would, but for this "excitement," remain unaffected.

NATURAL PURIFIED OILS

The Surakhany gas sands have for centuries been known to furnish a little highly refined volatile petroleum, of a straw color, denominated "white oil," which commanded a ready sale at one time for medicinal purposes and branches in the early arts. The Surakhany product has a specific gravity of 0.780, and its composition is—

Benzine	48.9 per cent
Kerosene	43.9 per cent
Other oils	7.2 per cent

Its highly volatile character, which causes a sensation of cold and pain when applied to the skin, has very likely led to its supposed curative powers, but in any case the extent of its use must have been strictly limited, as the quantity procurable is very small.

*From *Russia* for April, 1917. Copyright 1917 by R. Martens & Co. Inc.

This naturally purified oil is not confined to the Surakhany district, for an almost identical description of petroleum is occasionally discovered on the Saboontchy oil field at variable depths. The problem of its unexpected appearance, especially in wells to the north of the Romany Lake, cannot be easily solved, but it is possible that "white oil" is much more widely distributed throughout the strata than is usually suspected, and that its collection is unobserved owing to the peculiar conditions of boring. It is difficult to account for the presence of this "white oil," as its composition and properties are those of a distillation product, and it is by no means easy to imagine conditions under which distillation and condensation could take place.

SURFACE INDICATIONS OF OIL

Wherever the petroleum-bearing strata reach or nearly approach the surface of the ground, manifestations of such are generally indicated by a number of phenomena, which, to an experienced eye, may be usefully applied in forming an opinion of the value of the disturbed area. The oil-bearing strata of the Apsheron Peninsula, and their continuation along the Trans-Caucasian Railway almost to Tiflis, offer, in many places, exceptional opportunity for geological investigations of an extended character; for huge tracts of land where the oil formations outcrop are denuded of all surface alluvial soils and are devoid of vegetation. The Puta district, situated about 20 miles to the southwest of Baku, on the shores of the Caspian Sea, furnishes an excellent example of what is usually found in the oil regions, for the oil strata reach the surface at a very acute angle, and the outcrop of the beds may be traced for miles on a level plain when riding over the country, each distinct stratum being identified by its color, composition, exudations of oil, salt water, gas, or other features. Along some of the outcrops the effusions of oil and gas have formed hills of the locally termed *kir* (which is simply oil deprived of its lighter volatile constituents and solidified, giving it the consistency and appearance of asphalt), which has accumulated to the extent of thousands of tons, and totally changed the physical appearance of the plain. In some parts the process may be seen still in active progress, the gas and oil bubbling through the kir, and rendering the mass so soft that it will not support the weight of a man's body. Other lines of strata are dotted with the so-called mud volcanoes, and again others are recognizable for long distances by their exudations of salt and various gases.

THE TEMPLE OF THE FIRE WORSHIPERS

Historical records show that the gas of the Surakhany district—an area fringing the southeastern side of the Balakhany-Saboontchy oil field—has been known for very many centuries; and a temple of a curious style of architecture, situated within a few minutes' walk of the characteristic Tartar village of Surakhany, is said to have been one of the chief resorts of the Fire Worshipers, who flocked from all parts of India to perform a pilgrimage. The visitors continued to arrive in diminishing numbers until 1880, when the Russian Government put a stop to the entry of more pilgrims; but the devotees must have received a rude shock even before this date, on seeing a well-equipped pretroleum refinery constructed under the very walls of the temple, utilizing for industrial purposes the fire they had traveled thousands of miles to worship.

The building is not without great archæological interest. Around a courtyard of irregular and peculiar shape, the origin of which it is difficult to surmise, is a series of low cells lighted only by a small opening, scarcely 5 feet high, that serves the purposes of a door, none of which communicates with the adjoining chamber. Above the entrance to each compartment is a well-preserved inscription in Hindustani or Sanscrit, while within the dismal, unattractive cells will be found relics of a habitation that is impressive, on account of the simplicity and arrangement of the structure. One chamber, rather larger than the others, used by the priests to conduct therein their ceremonials and rites, contains an altar, to which the gas is admitted by orifices concealed in the masonry, and the lurid glare from this, when ignited, must have had an awe inspiring effect upon the ignorant and superstitious devotees who attended the *séances*. Another cell, provided with stone rings, carved from protruding blocks of stone, was evidently employed as a stable for the shelter of the pilgrims' animals; and yet another room was, according to the old Russian pensioner (a Crimean veteran) who acts as guide and caretaker, utilized as a kitchen and bakery. The remainder of the chambers encircling the courtyard were apparently sleeping-compartments, and the stone slabs, which either skirt the walls or are placed in excavations in the structure, were, presumably, the couches occupied by the believers when not busied in their devotions. As near as possible to the center of the rude heart-shaped courtyard a quadrangular building is located, arched on the four sides, and provided with a tower at each corner, to the summit of which gas is led by channels left in the stone work; and at a time when the gas pressure from the earth was much greater than it is today, the semi-transparent flames leaping up into the air must have created a profound impression upon those unacquainted with its origin. The entrance to the Surakhany temple is through a massive archway carved with clear inscriptions, and above this vestibule is a watch-tower, from which new arrivals could be welcomed.

PEASANT USE OF GAS

The peasants in the villages around Surakhany largely employ the gas for burning lime, as calcareous rocks abound in the neighborhood, cropping out in ridges at intervals. The Tartars declare that formerly a plentiful supply of gas could be obtained by digging a few feet into the fine, discolored sand, with which it is associated; but they now have to excavate to a depth of 40 to 80 feet before they reach gas in sufficient volume to be of practical use. Their mode of procedure is to excavate a square hole large enough to admit the body of a man with ease, his ascent and descent being usually accomplished by means of footsteps dug in the sides of the pit; but his escape is always assured in the event of danger of asphyxiation following a sudden inrush of gas by a rope secured to his waist, held by a man at the surface. When gas is reached, the pit is covered over, and passages or canals dug a few inches deep on the surface of the ground, and protected by stone slabs and soil, lead the gas to beneath conical heaps of limestone stacked for burning. The author, when first exploring these regions, prepared to ignite with a match one of the limestone stacks—for, when extinguished, the gas always escapes, there being no provision for storage or shutting off—but an alarmed attendant, whose agitation he did not understand, pulled him aside, and with a low whistle, and an expression full of meaning, pointed with his finger to the sky. He then lay flat on the ground, and ignited the gas by throwing several lighted matches into a recess beneath the limestone reserved for the purpose, thus escaping injury from the explosion that generally follows the ignition of a big pile. The fires, which are allowed to burn until calcination is completed, give a non-luminous flame, and are accompanied by much heat; and they are extinguished by suffocation with sand.

Experiments with Paper Tubes

TESTS were made with tubes prepared by the process of A. von Valois by rolling paper to the desired diameter and thickness of wall, fastening with a suitable adhesive, and coating. The tubes are intended to serve as pipes for gas and water. The specific resistance to direct hydraulic bursting pressure calculated according to the formula, $\frac{p.d}{2W}$, averaged 360 kilos. per sq. cm., where p is the bursting pressure in atmos., d the internal diameter, and W the thickness of the wall. The tubes were not appreciably affected by the prolonged action of coal gas, and some which had stood full of water for several weeks showed no perceptible swelling or loss of resistance. These paper tubes are only 1/6 to 1/8 the weight of lead pipes and resist 3–4 times the pressure for equal diameters. The joints of the paper pipes consist of tube sections slipped over the two ends to be united, the annular space being packed with a suitable composition. The jointed pipes burst at a considerably lower pressure than the single pipes and in some cases gave way at the joints. Tests for resistance to external pressure showed an average of 27.8 atmos., which is regarded as sufficient resistance to the pressure of the earth, provided the material did not become softened in course of time. Another set of trials was made with "Pertinax" tubes made from paper impregnated with synthetic resin and rolled under tension; the smallest internal diameter obtainable is 5 mm. Tensile tests were made with strips cut from the tubes, both air-dry and after steeping in water; the absorption of water caused a loss of strength of 22–35 per cent but increased the elongation on breaking; the modulus of elasticity was lowered by steeping. It appeared, however, that the absorption of water took place largely through the unprotected cut edges of the strips and to this extent the tests are not regarded as conclusive. Another make of paper tube was tested for absorption of water when the closed tube was allowed to stand full of water; the absorption was particularly large in the first hour and had not reached its limit after 282 hours; only the inner surface of the tube was softened, the outside not being visibly affected. For use with water, the suitability of paper tubes cannot be regarded as established, but further investigations are necessary before a definite judgment can be pronounced. The "Pertinax" tubes of small diameter should give good results for oil conduits in view of the well-known resistance of synthetic resins to oil. Bending tests with paper tubes have shown that they cannot be regarded as suitable for constructional purposes. The tensile strength of 10–18 kilos. per sq. cm. with a low specific gravity (1.2) is sufficient, but the compression strength (4.6 kilos. per sq. cm.) is too small and the extremely low modulus of elasticity would produce distortions of the structure even under very moderate stresses.—Note from *Journal Society Chemical Industry* on an article by M. RUDELOFF in *Mitt. K. Materialprüf.*

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